TAC H78-002

(NASA-CR-158594) HYDROGEN ENERGY: A BIBLIOGRAPHY WITH ABSTRACTS Quarterly Update, Apr. - Jun. 1978 (New Mexico Univ.) 44 p

N79-76984

Unclas

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A Bibliography with Abstracts
Quarterly Update June 30, 1978

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HYDROGEN ENERGY

A BIBLIOGRAPHY WITH ABSTRACTS

QUARTERLY UPDATE
APRIL-JUNE 1978

PREPARED BY THE

ENERGY INFORMATION PROGRAM

of the

TECHNOLOGY APPLICATION CENTER

JULY 1978

THE UNIVERSITY OF NEW MEXICO
ALBUQUERQUE, NEW MEXICO

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PREFACE

HYDROGEN ENERGY is a continuing bibliographic summary with abstracts of research and projections on the subject of hydrogen as a secondary fuel and as an energy carrier. The first volume was published in January, 1974 and is cumulative through December of 1973. Additional copies are available from the Technology Application Center, as are the quarterly update series for 1974, 1975, 1976, 1977, and the first quarter of 1978.

This update to HYDROGEN ENERGY cites additional references identified during the second quarter of 1978. It is the second in a 1978 quarterly series intended to provide "current awareness" to those interested in hydrogen energy.

For the reader's convenience, a series of cross indexes are included which track directly with those of the cumulative volume. See "Guide to Use of the Publication."

A library containing some of the articles and publications referenced in this update and the cumulative volume has been established and the Center will, on a cost-recovery basis, aid readers to obtain copies of any cited material. Although a considerable effort has been made to insure that the bibliography is complete, readers are encouraged to bring any omissions to the attention of this Center.

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GUIDE TO USE OF THIS PUBLICATION

A number of features have been incorporated to help the reader use this document. They consist of:

-- A TABLE OF CONTENTS listing general categories of subject content and indexes. More specific coverage by subject title/keyword and author is available through the appropriate index.

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-- A REFERENCE FORMAT containing the TAC citation number, title of reference, author, corporate affiliation, reference source, contract or grant number, abstract and keywords. The reference source tells, to the best of our knowledge, where the reference came from. If from a periodical, the reference source contains the periodical's title, volume number, page number and date. If for a report, the reference source contains the report number assigned by the issuing agency, number of pages and date.

-- An INDEX OF AUTHORS alphabetized by author's last name. A reference's author is followed by the reference's citation number. For multiple authors, each author is listed in the index.

-- An INDEX OF PERMUTED TITLES/KEYWORDS affords access through major words in the title and through an assigned set of keywords for each citation. A reference's title is followed by the reference's citation number. In the indexes, all the words pertaining to a reference are permuted alphabetically. Thus, the citation number for a reference appears as many times as there are major title words or keywords for that reference. The permuted words run down the center of an index page. The rest of the title or keywords appear adjacent to a permuted word. Since a title or set of keywords is allowed only one line per permuted word the beginning, the end, or both ends of a title or set of keywords may be cut off; or, if space permits, it will be continued at the opposite side of the page until it runs back into itself. A # indicates the end of a title or set of keywords while a / indicates where a title or set of keywords has been cut off within a line.

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10000 I. GENERAL: CONCEPTS, CONFERENCES, SURVEYS, AND REVIEWS

H78 10018 NEW FRONTIERS IN SOLAR AND OTHER ENERGY OPTIONS

Abdel-Hameed, M.F., El-Difrawi, A.A., (Northern Illinois Univ., Dekalb, IL), Development Analysis Associates, Inc., Cambridge, MA, 1976
No abstract available

(HYDROGEN FUELS, PHOTOSYNTHESIS, REVIEWS)

H78 10019 ENERGY

Anonymous, NASA Spec. Publ. SP-7043, 408 p., July 1977, CODEN:NSSPAW
This issue of Energy is a bibliography that lists 1000 reports, journal articles, and other documents announced between April 1, 1977 and June 30, 1977 in Scientific and Technical Aerospace Reports (STAR) or in International Aerospace Abstracts (IAA). The coverage includes regional, national, and international energy systems; research and development on fuels and other sources of energy; energy conversion, transport, transmission, distribution, and storage; with special emphasis on use of hydrogen and of solar energy. Also included are methods of locating or using new energy resources. Of special interest is energy for heating, lighting, for powering aircraft, surface vehicles, or other machinery. Each entry in the bibliography consists of a standard bibliographic citation, accompanied in most cases by an abstract.

(CONSERVATION, RESOURCES, STORAGE)

H78 10020 COMMERCIAL PRODUCTION OF HYDROGEN, CHLORINE, AND CAUSTIC: AN OVERVIEW

Cook, E.H., Tilak, B.V., (Hooker Chemicals and Plastics Corp., Niagara Falls, NY), Int. Energy Agency Water Electrolysis Workshop, Upton, NY, Sept. 23, 1975
No abstract available

(ECONOMICS, ELECTROLYSIS)

H78 10021 PROCESS FOR THE PREPARATION OF HYDROGEN

DuPont, A.A., U.S. Patent no. 4,045,546
A series of chemical reactions, based on cadmium with water reaction, is discussed.

(CADMIUM, THERMOCHEMICAL PROCESSES)

H78 10022 PRESENT AND FUTURE ABOUT HYDROGEN IN 1977

Galland, J., (Pergamon Press Ltd., Elmsford, NY), Hydrogen in Metals, V 1, 1977, In French
No abstract available

(DECOMPOSITION, NICKEL HYDRIDES, STORAGE)

H78 10023 AS THE OIL BEGINS TO RUN OUT

Garrett, K., (Automotive Eng., London, England), V 2:48-51, N3, 1977
No abstract available

(AUTOMOTIVE FUELS, COMBUSTION PROPERTIES)

H78 10024 HYDROGEN FUEL: A TECHNIQUE FOR ENERGY USE

Gregory, D.P., (Inst. of Gas Tech., Chicago, IL), Pergamon Press, Inc., Elmsford, NY, 1977
A brief review is given, indicating that economic, rather than technical problems, prevent widespread use of hydrogen.

(APPLIANCES, CHEMICAL FEEDSTOCKS, ECONOMY)

H78 10025 SOLAR, GEOTHERMAL, HYDROGEN, AND HYDRAULIC POWER

Hall, F.F., (Stanford Linear Accel. Center, Stanford Univ., Stanford, CA), ASCE J. Power Div., V 104:71-82, N1, 6 refs, Feb. 1978, CODEN:JPWEAM
A comprehensive energy policy is adopted here and abroad to solve the energy crisis. Certain features of such a policy are considered, including solar, geothermal, hydro-electric, and wind power plant applications. The possible use of weightless balloon collectors to reduce cost of solar-electric power plants is described. Present status of

geothermal power plants is reviewed. The use of hydrogen as a fuel and for energy conversion, transmission, and storage is described. Possible uses of untapped or remote sources of hydro-electric power are listed. The possible use of wind power is referred to.

(ENERGY RESOURCES, GENERATION)

H78 10026 ECONOMIC EVALUATIONS OF FUSION-BASED ENERGY STORAGE SYSTEMS IN AN ELECTRIC UTILITY

Hwang, W.G., (Texas Univ., Austin, TX), University Microfilms order no. 77-22,971, Univ. of Texas, Austin, TX, 1977

No abstract available

(BREEDING, COMMERCIALIZATION, HYBRID REACTORS)

H78 10027 LIQUID HYDROGEN AS ENERGY SOURCE: ECONOMIC CONSIDERATIONS THROUGH A COMPARISON WITH IMPORTED LIQUEFIED NATURAL GAS

Kandler, G., Gas Waerme Int., V 26:373-377, Aug. 1977, In German, A78-20516

The processes of liquefaction, transport, and distribution of natural gas, regarded as achieved technologies, are used as a basis for comparing the corresponding processes for liquid hydrogen. The main factor in the economic picture is the fact that the minimum energy per unit mass required for hydrogen liquefaction is about 13 times higher than that for natural gas liquefaction. Solar energy may be used in the process of obtaining hydrogen from water. The sun's energy will be without cost, but many investments must be made in order to develop a workable system. Estimates are made for the development of a complete liquid hydrogen import chain. Bearing in mind the increasing cost of fossil fuels, one concludes that liquid hydrogen can become competitive at the beginning of the 21st century.

(COST ANALYSIS, ECONOMIC FACTORS)

H78 10028 HYDROGEN GENERATION PROCESS, Quarterly Technical Progress Report, November 17, 1976-February 16, 1977

Koump, V., (Westinghouse Electric Corp., Advanced Energy Systems Div., Pittsburgh, PA), (ERDA), NTIS 64-(ESS09)78, 77 p., March 1977, contract no. EX-76-C-01-2262

The objective of this program is to assess the technical economic feasibility of a hybrid electrolytic-thermochemical hydrogen generation process, based upon the electrolysis of sulfurous acid. To do this, a multi-task program is being carried out to experimentally determine the operating characteristics of key process steps in the hydrogen-generating cycle and to perform engineering and economic analyses to evaluate the system. During the second quarter, considerable progress was made in the overall program.

(ECONOMICS, ELECTROLYSIS, RESEARCH PROGRAMS)

H78 10029 HYDROGEN AS A CARRIER OF ENERGY: AN ALTERNATIVE WITH A FUTURE

Ove, E.R., (Tech. Univ. Wien, Wien, Austria), Elektrotech. and Maschinenbau (EUM), Austria, V 94:408-412, N10, 24 refs, Oct. 1977, CODEN:EKMBA9, In German

The use and production of hydrogen is considered. It is shown to be suitable for basic purposes and to have an important future as a fuel which can be piped in liquid or gaseous form. Future use depends on the economics of large-scale production, which may be solved by the use of solar energy.

(ECONOMICS, RESOURCES, SOLAR POWER)

H78 10030 HYDROGEN

Reed, R.M., (Copr. Am. Chem., Louisville, KY), Conf. Proc. Energy Tech. Handbook, V 38: 4/26-4/43, 1977, CODEN:36YEAD, McGraw-Hill, New York, NY

Avail:Considine, D.M.

No abstract available

(REVIEW)

H78 10031 DESIGN TECHNIQUES FOR ENERGY CONSERVATION

Ring, T.A., Fox, J.M., (Bechtel, Inc., San Francisco, CA), Proc., Am. Pet. Inst., Sect. 3, V 55:697-713, 1976

No abstract available

(COMPRESSORS, COST, HYDROCRACKING)

H78 10032 ENERGY CONSIDERATIONS IN HHE POWER SYSTEMS

Scott, R.E., (Univ. of Petroleum and Minerals, Dharan, Saudi Arabia), Development Analysis Associates, Inc., Cambridge, MA, 1976
No abstract available

(ELECTROLYSIS, EVAPORATION, SOLAR ENERGY)

H78 10033 SYNTHETIC LIQUID FUELS DEVELOPMENT: ASSESSMENT OF CRITICAL FACTORS, Volume IV, ENERGY/ECONOMIC COMPARISON OF COAL-BASED AUTOMOTIVE ENERGY SUPPLY SYSTEMS

Steele, R.V., Sharma, K.J., Dickson, E.M., (Stanford Research Inst., Menlo Park, CA), ERDA-76-129/4, contract no. EY-76-C-03-0115, ERA citation no. 03:008598

Attention was focused on energy supply systems that could provide automotive energy. Six coal-based energy forms: gasoline refined from synthetic crude oil (syncrude), methanol, gasoline produced by Fischer-Tropsch synthesis, liquid hydrogen, liquid methane, and electricity were analyzed in terms of cost and energy consumption. Using only coal-based energy forms promoted consistency in the comparison of options.

(AUTOMOBILES, COAL LIQUEFACTION, EFFICIENCY)

H78 10034 TECHNICAL CONCEPTS AND ECONOMIC PROSPECTS FOR THERMAL HYDROGEN POWER PLANTS FOR PEAK LOAD GENERATION

Tanner, W., (Dornier System GMBH, Friedrichshafen, West Germany), In Int. Workshop on Hydrogen and its Perspectives, Liege, Belgium, Proc., (A78-13826 06-44), V 1:28, Nov. 15-18, 1976, Assoc. Des Ingenieurs Electriciens Sortis de L'Institut Electrotechnique Montefiore, 1977, In German, A78-18847

Attention is given to hydrogen-oxygen steam generators and closed gas-turbine processes with internal hydrogen-oxygen combustion, two techniques applicable to peak-load electrical generation. Costs of the electrolysis, the hydrogen and oxygen storage facilities, and the steam generators or gas-turbine adaptations needed for the nitrogen-oxygen power plants are analyzed. In addition, advantages of the hydrogen-oxygen power plants, including the absence of polluting emissions and the low cost of raw materials for fuel, are mentioned.

(BOILERS, ELECTROLYSIS, GAS TURBINES)

H78 10035 HYDROGEN AS AN ENERGY CARRIER

Tschegg, E., Wachter, W., (Inst. fur Angewandte Phys., Tech. Univ. Wien, Vienna, Austria), Oesterr. Ing.-Z., Austria, V 20:333-339, N10, Oct. 1977, CODEN: OSIZAN, In German

Favorable comments are discussed in regard to the "hydrogen economy;" the principles of the different methods proposed for the production of hydrogen (electrolytic, thermochemical, photolysis of water) are explained and compared.

(ENERGY RESOURCES, GENERAL REVIEW, HYDROGEN, PRODUCTION)

H78 10036 HYDROGEN AS AN ENERGY CARRIER, II

Tschegg, E., Waschter, W., (Inst. fur Angewandte Phys., Tech. Univ. Wien, Wien, Austria), Oesterr. Ing.-Z., Austria, V 20:386-392, N11, 50 refs, Nov. 1977, CODEN: OSIZAN, In German

This review deals with hydrogen as a peaking power source, as a fuel for air and ground transport, as an energy carrier for household and industry, and the storage and distribution of hydrogen.

(DISTRIBUTION, FUEL, STORAGE)

H78 10037 INTERNATIONAL WORKSHOP ON HYDROGEN AND ITS PERSPECTIVES, LIEGE, BELGIUM, Nov. 15-18, 1976, Proceedings, Volumes 1 & 2: $60.00

Workshop Sponsored by The Association des Ingenieurs Electriciens Sortis de L'Institut Electrotechnique Montefiore, Liege, Belgium, Assoc. des Ingenieurs Electriciens Sortis de L'Institut Electrotechnique Montefiore, A78-13827 to A78-13858), V 1:653, V 2:237, 1977, In French, English, and German, A78-13826

Coal gasification, partial oxidation, catalytic cracking, electrolysis, and thermochemical cycle techniques for obtaining hydrogen fuels are reviewed, and the use of hydrogen for aircraft fuel, automobile propulsion systems and peak-load electrical generation is discussed. Topics of the papers include fixed bed, fluidized bed and entrained phase coal gasification procedures, materials problems in advanced electrolysis systems, solid polymer electrolyte water electrolysis cells, computer codes for analyzing the feasibility of thermochemical cycles that produce hydrogen, the use of photosynthetic processes for hydrogen generation, hydrogen fuel transport and storage systems including those that use metal hydrides), a NASA study of the feasibility of adopting liquid hydrogen air craft fuel, hydrogen as used in chemical processing, and the toxicological effects of hydrogen.

(AIRCRAFT FUELS, ENERGY TECHNOLOGY, TOXICOLOGY)

H78 10038 HYDROGEN IN THE ENERGY SYSTEM OF THE NETHERLANDS, A POSSIBILITY FOR THE FUTURE

(Nijverheidsorganisatie TNO, Apeldoorn, Netherlands), 23 p., Sept. 1975, GRAI7805, ERA citation no. 02:058577
Avail:NTIS, US Sales only

The consequences of the shift from fossil to other energy sources to the extent that other resources are dominant were investigated. A scenario is presented on the rate at which, during the transition period, hydrogen can be introduced into the Dutch economy. Production, storage, transmission and distribution, environment and safety, and utilization in stationary units and vehicles are considered. It could be concluded that there are no serious objections in connection with the transition to the use of hydrogen as fuel.

(DISTRIBUTION, ELECTROLYSIS, ENVIRONMENTAL EFFECTS)

H78 10039 ENVIRONMENTAL ASSESSMENT OF THE HYGAS PROCESS, Monthly Progress Report, May 1-May 31, 1977

(Inst. of Gas Tech., Chicago, IL), (ERDA), 21 p., Sept. 1977, Contract no. EX-76-C-01-2433, GRAI7808, ERA citation no. 03:007825

The environmental assessment program for the HYGAS Process was started with HYGAS Tests 55 through 58, which utilized Montana sub-bituminous coal (nonagglomerating) from the Rosebud seam. Beginning with HYGAS Test 59, pilot plant studies were started with Illinois no. six bituminous coal from the Peabody no. 10 mine. In the HYGAS tests with sub-bituminous coals, light-oil samples recovered from the steam stripper were analyzed for organic constituents by gas chromatography-mass spectrometer (GCMS) techniques. Phenols were not detected in the stripped oil samples; consequently, samples of the coal feed oil slurry were recovered and analyzed primarily for phenols.

(AGGLOMERATION, CHEMICAL ANALYSIS, FORECASTING)

H78 10040 EVALUATION OF THE USE OF HYDROGEN AS A SUPPLEMENT TO NATURAL GAS

(Ad Hoc Committee on the Use of Hydrogen for Natural Gas Supplementation, ERDA), 71 p., June 1977, GRAI7809

The potential for mid-term (1985-2000) commercial application of the use of hydrogen for blending into the present natural gas delivery system as an energy supplement was studied. Successful development of advanced electrolyzer technology and availability of low-cost "off-peak" and "spinning reserve" electric-generating capacity are basic to this concept. Because no source was found that would make such a concept economically viable in the near future, the committee determined that a major federally funded R.D.&D. program aimed at proving the technical feasibility is not justified within the next five years.

(ECONOMICS, FINANCIAL INCENTIVES, PRODUCTION)

20000 II. PRODUCTION

H78 20006 THEORY OF HYDROGEN PRODUCTION IN A PHOTOELECTROCHEMICAL CELL

Bockris, J.O'M., Uosaki, K., (Flinders Univ., Bedford Park, Australia), Development Analysis Associates, Inc., Cambridge, MA, 1976
No abstract available

(EFFICIENCY, PHOTOCHEMISTRY, TITANIUM OXIDES)

H78 20007 ELECTROCHEMICAL ENERGY CONVERSION, II, UTILITIES, MARINE AND SPACE APPLICATIONS

Hirschfeld, F., Mech. Eng., V 99:28-34, N7, July 1977
No abstract available

(NICKEL-CADMIUM BATTERIES, SPACE VEHICLES, SULFUR TRIOXIDE)

H78 20008 CONCEPTUAL DESIGN OF LARGE-SCALE WATER ELECTROLYSIS PLANT USING SOLID POLYMER ELECTROLYTE TECHNOLOGY

Nuttall, L.J., (GE Co., Wilmington, MA), Int. J. Hydrogen Energy, V 2:395-403, N4, 1977, CODEN:IJHEDX

The key to the applicability of water electrolysis as a means for generation of hydrogen in bulk quantities is the achievement of high efficiencies (i.e., over 90 percent) at high enough current densities to keep the capital costs within economic bounds. The solid polymer electrolyte (SPE) water electrolysis technology developed by the General Electric Company is now demonstrating these efficiencies at current densities up to 500 A/ft^2, and the results of recent laboratory testing show a potential for increasing this to 2000 A/ft^2 within the next 10 years. The design and development status of a scaled-up electrolysis cell suitable for large-sized hydrogen generation plants is described. Estimated capital costs and operating costs are projected from which the resultant hydrogen costs are calculated.

(DEVELOPMENT, EFFICIENCIES)

H78 20009 POSSIBILITIES FOR IMPROVING THE ELECTROLYSIS OF WATER IN ALKALINE SOLUTIONS

Sohm, J.C., (Grenoble Universite, Grenoble, France), Graziotti, R., (Electricite De France, Paris, France), In Int. Workshop on Hydrogen and its Perspectives, Liege, Belgium. Proc., (A78-18826 06-44), V 1:29, Nov. 15-18, 1976, Assoc. Des Ingenieurs Electriciens Sortis de L'Institut Electrotechnique Montefiore, 1977, In French, A78-18831

Current density, temperature, and pressure are studied as critical parameters for the electrolysis of water in alkaline solutions to produce hydrogen fuel. In addition, the use of nickel-based alloy electrodes as catalytic activators is mentioned. The adoption of high-temperature and high-pressure electrolytic processes has resulted in problems connected with the durability of diaphragms and other components of the electrolytic systems. The durability of metals and plastics (such as polysulfone) in alkaline solutions is therefore analyzed. Emphasis is placed on currently available commercial apparatus for the electrolytic processes.

(CURRENT DENSITY, PRESSURE EFFECTS, TEMPERATURE EFFECTS)

H78 20503 PLANT FOR THE PRODUCTION OF HYDROGEN THROUGH UTILIZATION OF HEAT ENERGY OBTAINED FROM A GAS-COOLED NUCLEAR REACTOR

Baumgaertner, H., Barchewitz, E., (To Hochtemperatur-Reactorbau GMBH), Aug. 30, 1977, Priority date Nov. 23, 1974, Federal Republic of Germany, US Patent no. 4,045,285
No abstract available

(HYDROCARBONS, PROCESS HEAT REACTORS, STEAM)

H78 20504 REVIEW OF THE POTENTIAL FOR THE USE OF NUCLEAR REACTORS FOR HYDROGEN PRODUCTION

Worley, N.G., (Babcock and Wilcox Ltd., London, U.K.), Energy Dig., London, V 6:40-44, N3, June 1977

No abstract available.

(ELECTROLYSIS, FORECASTING, PLANNING)

H78 21006 IRREVERSIBILITIES IN THERMOCHEMICAL CYCLES FOR HYDROGEN PRODUCTION BY WATER DECOMPOSITION

Cox, K.E., Natarajan, M., (Univ. of New Mexico, Albuquerque, NM), Proc. of the 12th Intersoc. Energy Conversion Engng. Conf., V 1:947-950, 12 refs, Aug.-Sept. 2, 1977, Am. Nuclear Soc., IEEE, et al., Washington, D.C.

Shown are major irreversibility gains occurring due to large exothermic heat losses, as well as due to separation work. The use of solution chemistry and gas phase reactions with condensable products may be ways to decrease the irreversibility in thermochemical cycles. The irreversibility is found to vary with the thermal efficiency; the lower the irreversibility produced, the higher the cycle's efficiency.

(CONDENSABLE PRODUCTS, SOLUTION CHEMISTRY, WATER DECOMPOSITION)

H78 21007 LASL THERMOCHEMICAL HYDROGEN PROGRAM STATUS ON OCTOBER 31, 1977

Cox, K E., Bowman, M.G., (Los Alamos Scientific Lab., Los Alamos, NM), Annual DOE Chemical Energy Storage and Hydrogen Energy Systems Contract Review Mtg., Nov. 16, 1977

Cycles using sulfuric acid as an intermediate are discussed.

(BISMUTH SULFATES, SULFURIC ACID)

H78 21008 DESIGN AND EVALUATION OF THERMOCHEMICAL CYCLES: THE WORK PERFORMED AT J.R.C. ISPRA ESTABLISHMENT

De Beni, G., (Euratom and Comitato Nazionale per L'Energia Nucleare, Centro Comune di Ricerche, Ispra, Italy), In Int. Workshop on Hydrogen and its Perspectives, Liege, Belgium, Proc., (A78-18826 06-44), V 1:19, Nov. 15-18, 1976, Assoc. des Ingenieurs Electriciens Sortis de L'Institut Electrotechnique Montefiore, 1977, A78-18835

Attention is given to such proposed water-splitting thermochemical cycles as the hydrolysis of calcium bromide, iron-chloride cycles, and hybrid cycles involving sulfuric acid decomposition. Computer codes written for the evaluation of the thermal efficiency and the heat coupling of chemical plants with heat sources are reviewed, with emphasis on their utility as thermochemical cycle design aids. Other considerations relevant to the design of cycles include the cost of separating materials, problems in the fluidification of solids, and thermodynamic limits related to the number of reactions in pure and hybrid cycles. A sulfur dioxide-iodine cycle which uses excess liquid sulfur dioxide as a means for separating hydriodic and sulfuric acid is held to be very promising.

(ENERGY TECHNOLOGY, SULFURIC ACID, THERMOCHEMISTRY)

H78 21009 THERMOCHEMICAL HYDROGEN PRODUCTION: ENGINEERING EFFICIENCY AND ECONOMICS

Funk, J.E., (Univ. of Kentucky, Lexington, KY), Knoche, K.F., In Int. Workshop on Hydrogen and its Perspectives, Liege, Belgium, Proc., (A78-18826 06-44), V 1:25, Nov. 15-18, 1976, Assoc. des Ingenieurs Electriciens Sortis de L'Institut Electrotechnique Montefiore, 1977, A78-18834

This paper presents a discussion of efficiency and costs for thermochemical hydrogen production processes. The effect of maximum process temperature on efficiency for four sulfur cycles is shown. The most recent results on the hybrid sulfuric acid processes are included, along with a comprehensive flow sheet for this process. The results of an energy analysis, which clearly show where the irreversibilities occur in the plant and how they influence the nuclear reactor power rating, is also presented. Finally, the effect of overall process thermal efficiency and chemical plant investment cost on hydrogen production cost is developed.

(COST EFFECTIVENESS, IRREVERSIBLE PROCESSES, SULFURIC ACID)

H78 21010 PRODUCTION OF HYDROGEN BY THERMOCHEMICAL REACTIONS

Hoffman, H., (Univ., Erlangen-Nuernberg, Erlangen, Germany), Chem.-Ing.-Tech., V 48:87-90, N2, Feb. 1976, In German
No abstract available

(HALIDES, IRON CHLORIDES, TRANSITION ELEMENT)

H78 21011 REVISED FLOW SHEET AND PROCESS DESIGN FOR THE ZnSe THERMOCHEMICAL CYCLE

Krikorian, O.H., Otsuki, H.H., (California Univ., Lawrence Livermore Lab., Livermore, CA), 11 p., Oct. 27, 1977, Rept. no. CONF-77131-1, contract no. W-7405-ENG-48, COE Annual Chem. Energy Storage and Hydrogen Energy System Contracts Review, Baltimore, MD, Nov. 16, 1977
Avail:NTIS

The authors have completed a preliminary process design, flow sheet, and an economic analysis of an improved version of the ZnSe cycle for hydrogen production. The amount of $ZnSO_4$ that needs to be decomposed at high temperatures has been reduced by a factor of two in this revised cycle, thereby both lowering overall heat requirements and spreading out the prime heat required over a broader temperature range than before. Corresponding improvements have been achieved in both cycle efficiency and equipment costs. Assuming a VHTR nuclear reactor heat source and incorporating special equipment designs for critical steps in the cycle, we now obtain an overall cycle efficiency of about 40 percent and a hydrogen production cost of about \$13/GJ. We believe that this cost is conservative at this point of cycle development because the input data on reaction rates and equipment lifetimes have been conservative, and the analysis has not been optimized.

(ECONOMICS, ZINC SELENIDES)

H78 21012 CHEMICAL AND PROCESS DESIGN STUDIES OF THERMOCHEMICAL CYCLES FOR HYDROGEN PRODUCTION

Krikorian, O.H., Pearson, R.K., Otsuki, H.H., Elson, R.E., (California Univ., Lawrence Livermore Lab., Livermore, CA, ERDA), 17 p., April 13, 1977, Rept. no. CONF-770436-1, Contract no. W-7405-ENG-48, Thermochem. Hydrogen Res. Mtg., Oak Ridge, TN, April 18, 1977
Avail:NTIS

The ZnSe thermochemical cycle has been modified recently to convert $ZnCl_2$ directly to ZnO and reduce the amount of $ZnSO_4$ that needs to be decomposed at high temperatures. The modified cycle shows significant advantages in efficiency and process design. Exploratory research on the reaction, $ZnCl_2$ (l) + H_2O (g) implies ZnO (s) + 2HCl (g), showed the reaction rate to be quite rapid; i.e., 53 percent of equilibrium being attained in 2s at 900 K. Detailed research has also been conducted on the kinetics and mechanism of decomposition of H_2Se. A process design and economic analysis of the modified cycle indicates the following: overall thermal efficiency is approximately 42 percent, and hydrogen production cost is approximately \$13.22/10^6 kj in 1976 dollars for a plant producing 27,000 kg H_2/h. In the CH_4-CH_3OH cycle, attempts thus far to convert CH_3OH to CH_4 by reaction with metal oxides and SO_2 have led to unacceptably high amounts of H_2O, CO_2, and organic compounds as by-products. In future studies on this cycle, the lower oxides of As, Sb, and V will be explored as reducing agents for CH_3OH.

(COST, EFFICIENCY, PRODUCTION)

H78 21013 METHOD FOR HYDROGEN PRODUCTION BY WAY OF A THERMOCHEMICAL CYCLIC PROCESS

Koch, C., (Siemens A.G., Berlin, Germany F.R., Siemens A.G., Muenchen, Germany F.R.), Dec. 2, 1976, Patent no. 2,521,246/A, In German
No abstract available

(HYDROCHLORIC ACID, LEAD CHLORIDES, LEAD OXIDES)

H78 21014 INDUSTRIAL METHOD OF HYDROGEN PRODUCTION

Mascarello, J.M., Godin, P., Millet, J., (Electricite de France, 75-Paris Service Nat'l, Paris, France), Oct. 2, 1975, Patent no. 2,511,906/A, In German
No abstract available

(COPPER CHLORIDES, PYROLYSIS, THERMOCHEMICAL PROCESSES)

H78 21015 CONVERSION OF AMMONIA INTO HYDROGEN AND NITROGEN BY REACTION WITH A SULFIDED CATALYST

Mathews, C.W., ERDA), Filed May 11, 1976, US Patent no. 4,032,613, June 28, 1977
No abstract available

(COAL GASIFICATION PLANTS, IRON SULFIDES)

H78 21016 THERMOCHEMICAL PRODUCTION OF HYDROGEN

Sayigh, A.M., Sabbagh, J.A., Abdul-Salam, E., Abdul-Azeem, E.M., (Univ. of Riyadh, Riyadh, Saudi Arabia), Development Analysis Associates, Inc., Cambridge, MA, Heliotechnique and Development, V 1, 1976
No abstract available

(BROMINE COMPOUNDS, IRON COMPOUNDS, ZINC COMPOUNDS)

H78 21017 PHOTOLYSIS OF WATER AND PHOTOREDUCTION OF NITROGEN ON TITANIUM DIOXIDE

Schrauzer, G.N., Guth, T.D., (Univ. of California, San Diego, CA), J. Am. Chem. Soc., V 99:7189-7193, N22, Oct. 26, 1977
No abstract available

(CATALYTIC EFFECTS, IRON ADDITIONS, TITANIUM OXIDES)

H78 21018 DEVELOPMENT OF A SULFUR-IODINE THERMOCHEMICAL WATER-SPLITTING CYCLE FOR HYDROGEN PRODUCTION

Schuster, J.R., Russel, J.L.Jr., McCorkle, K.H., Mysels, K.J., Norman, J.H., O'Keefe, D.R., Sharp, R., Stowell, S.A., Trester, P.W., Williamson, D.G., (General Atomic Co., San Diego, CA), Proc. of the 12th Intersoc. Energy Conversion Engng. Conf., V 1:920-927, Aug. 28-Sept. 2, 1977, Am. Nuclear Soc., La Grange Park, IL, IEEE, et al., Washington, D.C.

A three-step thermochemical water-splitting cycle is being developed for the purpose of producing hydrogen from nonfossil energy sources. This cycle, which employs sulfur and iodine, can be conducted as an all liquid-and-gas process, using concentrated solar heat or heat from a high-temperature gas-cooled reactor (HTGR). All chemical reactions have been shown to proceed rapidly and cleanly. In coupling the cycle to an HTGR, process engineering has produced an estimate of 41.4 percent for net thermal efficiency which will be obtained for the next flow sheet. Material corrosion testing has shown some commercial construction.

(NONFOSSIL, THERMAL EFFICIENCY, THREE-STEP)

H78 21019 PRODUCTION METHOD FOR HYDROGEN BY THERMOCHEMICAL DECOMPOSITION OF WATER

Takashi, H., 1977
Avail:NTIS
No abstract available

(IRON HYDROXIDES, MAGNESIUM OXIDES, THERMOCHEMICAL PROCESSES)

H78 21020 DEVELOPMENT OF THE STEAM-IRON PROCESS FOR HYDROGEN PRODUCTION, Project 9010 Quarterly Report no. 1, July 1-Sept. 30, 1976

(Inst. of Gas Tech., Chicago, IL), Aug. 1977
Avail:NTIS
No abstract available

(CHARS, IRON OXIDES, RESEARCH PROGRAMS)

H78 22014 PROCESS FOR THE CONVERSION OF COAL INTO A COMBUSTIBLE GAS

Agarwal, J.C., Ahner, W.D., (USS Engineers and Consultants, Inc., Pittsburgh, PA), March 13, 1975, Patent no. 2,443,740/A, In German
No abstract available

(CHEMICAL COMPOSITION, COAL PREPARATION, FLOW SHEETS)

H78 22015 HYDROGEN FROM COAL CHAR IN A CONTINUOUS ELECTROFLUID (EXPERIMENTAL) REACTOR

Beeson, J.L., Pulsifer, A.H., Wheelock, T.D., Ind. Eng. Chem., Process Des. Dev., V 13: 159-164, N2, April 1974
No abstract available

(CHEMICAL REACTORS, FLUIDIZED BED)

H78 22016 CATALYTIC CONVERSION OF COAL ENERGY TO HYDROGEN, Monthly Report, May 1-May 31, 1977

Starkovich, J.A., Pinkerton, J.D., Motley, E., (TRW, Inc., Redondo Beach, CA), 15 p., June 1977, GRAI7807, contract no. EX-76-C-01-2206

The overall objective of the program is to develop a preliminary assessment of the potential of a hydrogen generation process, based upon reactions involving char, steam, lime, and metal salt additives. Design, construction, and preliminary checkout tests of the elevated pressure fluid bed reactor have been completed. A review of the safety of operation of the reactor system was completed, and TRW management approval to operate the system for char gasification studies up to a temperature of 750 C and a pressure of 150 psi was granted. Catalyst transport studies were completed under the Gasification Reaction Physical-Chemical Properties Task. In the studies completed, potassium carbonate catalyst, applied to a high surface area silicon carbide support material and immersed in a char bed, was shown to be mobile during the char-steam reaction and able to catalyze, though somewhat ineffectually, the char gasification reaction(s). Gasification experiments were carried out in the fixed-bed reactor system to determine the effects which a small oxygen partial pressure would have on the product composition and gasification rate of the potassium carbonate catalyzed steam-char-limestone reaction. The engineering analysis effort has paralleled the laboratory research to the extent that the selected laboratory data have been incorporated into an updated version of the conceptual commercial process design for the TRW coal to H_2 process.

(FEASIBILITY STUDIES, GASIFICATION)

H78 22017 EDS COAL LIQUEFACTION PROCESS DEVELOPMENT, Phase III B Monthly Technical Progress Report, July 1-Aug. 31, 1977

(Exxon Research and Engng. Co., Linden, NJ), 48 p., 1977, contract no. EF-77-A-01-2893 Avail:NTIS

The process variable study initiated during Phase IIIA with Wyoming sub-bituminous coal was resumed in the 50 pound/day Recycle Coal Liquefaction Unit. The variables investigated were liquefaction residence time and temperature. Studies on the one ton/day Coal Liquefaction Pilot Plant continued with Wyoming sub-bituminous coal to obtain additional yield information at longer residence times than those previously tested. Bituminous coal operators were then resumed to study the effects of increasing the end-point of the solvent. There were no operational problems and there were no apparent yield differences between the standard solvent and the higher end-point solvent. A high molecular weight cationic flocculant effectively settled both Illinois and Wyoming coal fines from a water slurry. This additive may be used in the disposition of coal fines from the 250 ton/day Exxon Coal Liquefaction Pilot Plant to an existing refinery solids settling pond. Analyses of fines from studies in the Fluidized Bed Unit showed the ash content of the -325 mesh material to be consistently greater then 99 wt. percent.

(COAL FINES, LIQUEFACTION, MATERIALS TESTING)

H78 22018 PREPARATION OF A COAL CONVERSION SYSTEMS TECHNICAL DATA BOOK, PROJECT 8979 Monthly Status Report, Aug. 1-Aug. 31, 1977

(Inst. of Gas Tech., Chicago, IL), 50 p., Oct. 1977, contract no. EX-76-C-01-2286

Various correlations for estimating the calorific value of coal from its elemental composition are compared using an extended data base of Americal coals. Charts that give partial pressures of NH_3 and H_2S in the HN_3 - H_2S -H_2O subsystem are presented. The equilibrium constants for reactions of interest in coal conversion processes are presented as functions of temperature. Three correlations for saltation velocity in horizontal gas-solid transport are evaluated, using available data on saltation velocities. Experimental and calculated fluid temperature profiles in coal-slurry heaters are compared for a low solvent to coal ratio (S/C = 1.69). Heat transfer coefficient curves (calculated using three different heat transfer correlations) are presented as functions of temperature for various solvent/coal ratios and fluid velocities.

(CHEMICAL REACTIONS, HEAT TRANSFER, PNEUMATIC TRANSPORT)

H78 23004 POTENTIAL FUEL PRODUCTION FROM MAGMA

Northrup, C.J.M.Jr., Gerlach, T.M., Modreski, P.J., Galt, J.K., (Sandia Labs., Albuquerque, NM), 33 p., June 1977, contract no. EY-76-C-04-0789
Avail:NTIS

Recent calculations and measurements indicate that basaltic magma is a new, extensive source for fuels (hydrogen, carbon monoxide, and methane). The fuel production processes have been found to occur in nature as well as the laboratory, and as a result, the work indicates that current concepts of geothermal energy can be broadened beyond producing only steam and heat. When magma is considered as a geothermal resource, its use for the direct production of fuels should be included. It is possible to generate several mole percent hydrogen when water-rich fluid is equilibriated with the ferrous and ferric iron in magma. The basis of the fuel production processes, the fuel yields for injected water and water plus natural organic matter, and the increased geothermal resources that would be made available by these processes are described.

(GEOTHERMAL ENERGY, ROCK-FLUID INTERACTIONS)

H78 23201 FUELS AND CHEMICALS FROM CROPS

Bungay, H.R., Ward, R.F., (US Department of Energy, Div. of Solar Energy, Washington, D.C.), In Fuels from Waste, (A78-27801 10-44), p. 105-120, 1977, Academic Press, New York, NY, A78-27808

Biomass conversion processes designed to provide fuels and chemicals in the long-term are discussed. Conversion processes for both aquatic and terrestrial plants are considered. Products of biomass conversion include synthesis gas, ammonia, methanol, formaldehyde, alcohols, aromatics, ethylene, heterocyclics, gum naval stores, and cellulose derivatives. Anaerobic digestion, pyrolysis, gasification, fermentation processes, and the production of hydrogen by biophotolysis are the chief processing methods applicable to biomass conversion.

(BIOMASS, GASIFICATION, WASTE UTILIZATION)

H78 23202 HYDROGEN FROM SUNLIGHT: THE BIOLOGICAL ANSWER, DEVELOPMENT OF A LOW-COST BIOLOGICAL SOLAR PANEL

Friedland, J., (Dade County Public Schools, Dade County, FL), Proc. of the 1977 Annual Meeting of the Am. Section of the Int. Solar Energy Soc., V 1, Sections 14-25, Solar World Meeting, Orlando, FL, June 6, 1977

No abstract available

(BIOSYNTHESIS, MATERIALS TESTING, PHOTOSYNTHESIS)

H78 23203 POTENTIALS OF HYDROGEN PRODUCTION THROUGH BIOPHOTOLYSIS

Kramfitz, L.O., (Case Western Reserve Univ., Cleveland, OH), Symp. on Clean Fuels from Biomass and Wastes, Orlando, FL, Jan. 25, 1977, Inst. of Gas Tech., Chicago, IL, March 1977

Clean fuel as a result of biomass and wastes is discussed.

(ALGAE, BACTERIA, CATALYSIS)

H78 23204 PROCESS FOR GENERATING SYNTHESIS GAS

Marion, C.P., Mamaronek, N.Y., Reynolds, B., (Texaco Development Corp., New York, NY), July 1, 1976, Patent no. 2,249,961/C, In German

No abstract available

(CHEMICAL REACTORS, NOZZLES, OXIDATION PROCESS)

H78 23205 PHOTOSYNTHETIC PRODUCTION OF HYDROGEN

Neil, G., Nicholas, D.J.D., Buckris, J.O'M., McCann, J.F., (Flinders Univ., Bedford Park, Australia), Heliotechnique and Development, V 1, 1976, Development Analysis Associates, Inc., Cambridge, MA

No abstract available

(PHOTOSYNTHESIS, SOLAR ENERGY CONVERSION)

H78 23206 THE PRODUCTION OF HYDROGEN THROUGH USE OF THE PHOTOSYNTHETIC ACTION OF PLANTS

Sironval, C., Liege Universite, Liege, Belgium), Int. Workshop on Hydrogen and its Perspectives Proc., Liege, Belgium, (A78-13326 06-44), V 1:17, Nov. 15-18, 1976, Assoc. des Ingenieurs Electriciens Sortis de L'Institut Electrotechnique Montefiore, 1977, In French, A78-13336

The culture of microalgae for fermentation reactions, and the construction of bioreactors containing components of green plants or bacteria are proposed to utilize photosynthetic processes for the production of hydrogen fuels. In particular, the culture of bacteria of the genus Clostridium is suggested for hydrogen production from fermentation; recovery of nitrogen and phosphorus from this process, as well as from methane production from the genus Methanobacter, is foreseen. The use of hydrogenase synthesized by algae or bacteria (e.g., green algae of the genus Scenedemus) for hydrogen production is also considered.

(ALGAE, FERMENTATION, MICROALGAE)

H78 23606 USE OF SOLAR ENERGY FOR DIRECT AND TWO-STEP WATER DECOMPOSITION CYCLES

Bilgen, E., (Ecole Polytechnique, Montreal, Canada), DuCarroir, M., Foes, M., Sibieude, F., (CNRS, Laboratoire des Ultra-Refractaires, Odeillo, Pyrenees-Orientales, France), Trombe, F., (CNRS, Laboratoire de L'Energie Solaire, Odeillo, Pyrenees-Orientales, France), Int. J. Hydrogen Energy, V 2:251-257, Oct. 27, 1977, A78-16048

The feasibility of using concentrated solar energy at high temperatures to decompose water is experimentally demonstrated. Preliminary studies show that direct decomposition of water at 2000-2500 C is possible, and that the main development should be directed toward reactor design and the separation of product gases. On the other hand, it is shown that two-step thermochemical cycles for hydrogen production are feasible when the reactions are carried out at appropriate high temperatures in a solar furnace. The thermal decomposition of zinc oxide, suitable for such a two-step cycle, is studied in detail.

(HYDROGEN PRODUCTION, THERMODYNAMIC EFFICIENCY, ZINC OXIDES)

H78 23607 SOLAR ENERGY UTILIZATION: THE PHOTOCHEMICAL APPROACH

Broda, E., (Univ. of Vienna, Vienna, Austria), Development Analysis Associates, Inc., Cambridge, MA, 1976

No abstract available

(BACTERIA, PHOTOSYNTHESIS)

H78 23608 HYDROGEN AND OXYGEN FROM WATER

Fletcher, E.A., Moen, R.L., (Dept. of Mech. Engng., Univ. of Minnesota, Minneapolis, MN), Science, V 197:1050-1056, N4308, 25 refs, Sept. 9, 1977, CODEN: SCIAS

A one-step, high-temperature process is considered. The effusional separation of the equilibrium components of water substance heated to temperatures in the range 2000-3000 K by a concentrating solar collector is exemplified by the one at Odeillo-Font Romeu, France.

(EQUILIBRIUM COMPONENTS, PRODUCTION, THEORETICAL)

H78 23609 SOLAR PHOTOLYSIS OF WATER

Ryason, P.R., (NASA, Pasadena, CA), 6 p., Filed Feb. 13, 1976, Patented Aug. 30, 1977, Rept. no. PATENT-4 045 315, PAT-APPL-658 132, STAR1523
Avail:Commissioner of Patents, $0.50

Hydrogen is produced by the solar photolysis of water in a first photooxidation vessel with a transparent wall in the presence of a water-soluble photooxidation reagent and an insoluble hydrogen recombination catalyst. Simultaneously, oxygen is produced in a second photoreduction reactor with a transparent wall in the presence of an insoluble photoreduction reagent catalyst. When spent, the solution from the first reactor is fed into the second reactor. A reaction occurs in the dark in which the redox reagents are regenerated, and the regenerated photooxidation reagent solution is recycled to the first reactor. The photoreduction-catalyst is a bifunctional reagent catalyst including a transition metal salt together with a hydroxyl or chlorohydroxyl decomposition catalyst of high area.

(CATALYSIS, PHOTOOXIDATION)

H78 23610 SOLAR HYDROGEN GENERATOR

Sebacher, D.I., Sabol, A.P., April 26, 1977, US Patent no. 4,019,368

No abstract available

(ENERGY CONVERSION, PRODUCTION)

30000 III. UTILIZATION

H78 30007 FUTURE FUELS FOR AVIATION

Barrere, M., (Onera, Chatillon-Sous-Bagneux, Hauts-de-Seine, France), Congres Int. Aeronautique, 13th, Paris, France, p. 21-31, N66, June 2-3, 1977, L'Aeronautique et L'Astronautique, A78-13021

A review is presented of global energy consumption in terms of the percentages of various sources utilized. Fuel characteristics currently required by aircraft engines are discussed, noting their precise physical and chemical effects on engine operation. Suggestions are made with regard to the development of policies for both fuel consumption reduction and the development of new fuel sources, such as (1) economic analyses of fuels currently used and their projected availability, (2) the potential combination of oil-derived and synthetic fuels, and (3) the creation of wholly synthetic fuels, perhaps based on methane and hydrogen.

(CHEMICAL PROPERTIES, POWER EFFICIENCY, SYNTHETIC)

H78 30008 THE LIQUID HYDROGEN OPTION FOR THE SUBSONIC TRANSPORT, A Status Report

Korycinski, P.F., (NASA Langley Research Center, Hampton, VA), Proc. of the 12th Intersoc. Energy Conversion Engng. Conf., V 1:964-972, 22 refs, Aug. 28-Sept. 2, 1977, Am. Nuclear Soc., La Grange Park, IL, IEEE, et al., Washington, D.C.

A liquid hydrogen fuel option for subsonic air transports is studied. In addition to continued air transport design studies, elements of this option include economical production of hydrogen, efficient liquefaction of hydrogen, materials for long service life LH_2 fuel tanks, insulation materials, LH_2 fuel service and installations at major air terminals, assessment of LH_2 hazards, and the engineering definition of an LH_2 fuel system for a large subsonic passenger air transport.

(AIR TERMINALS, ECONOMICAL PRODUCTION, INSULATION MATERIALS)

H78 30009 CURRENT AND FUTURE FUELS FOR TRANSPORT AIRCRAFT

Troadec, J.-P., (Direction Generale de L'Aviation Civile, Paris, France), France Transports-Aviation Civile, p. 46-47, Fall, 1977, In French, A78-18669

Some of the basic characteristics of liquid hydrogen and methane as aircraft fuels are compared with the characteristics of the current Jet A and Synthetic Jet A fuels. Liquid hydrogen's advantages include an elevated ratio of calorific value to mass, its nonpolluting combustion, and the fact that it can be obtained nearly everywhere without large transportation costs. Its disadvantages include the storage problem, the safety question, and its cost. Liquid methane has smaller production cost and requires less energy for production than liquid hydrogen.

(CRYOGENIC STORAGE, HEAT MEASUREMENT, HYDROCARBON DUELS)

H78 30010 AERODYNAMICS STUDY OF A DUAL-FUEL HYPERSONIC AIRCRAFT CONCEPT

(NASA, Langley Res. Center, Langley Station, VA), (Lockheed-California Co., Burbank, CA), (MOD-000)NAS1-15241, Feb. 1-Sept. 30, 1978, X78-10489

No abstract available

(AIRCRAFT MODELS, PROPULSION SYSTEM, WIND TUNNEL MODELS)

H78 33008 PERFORMANCE EVALUATION OF A CATALYTIC PARTIAL OXIDATION HYDROGEN GENERATOR USING TURBINE ENGINE FUELS

Clayton, R.M., (Jet Propulsion Lab., Pasadena, CA), 43 p., Oct. 1, 1976-April 30, 1977, Proj. no. 3048
Avail:NTIS

Operation of a catalytic partial oxidation reactor under simulated turbine engine idle power air-state conditions, using a conventional aviation turbine fuel (JP-5) and an unconventional fuel (blend of JP-5/xylene), is shown to produce a "fuel gas" stream of near theoretical equilibrium composition at very fuel-rich A/F ratios in the range of 5.0-5.6. The combustibles in the fuel gas comprise about six percent H_2 and 93 percent CO by mass, and therefore the fuel gas exhibits superior lean-burning qualities relative to the fuel feedstock. The concept of using the very fuel-rich partial oxidation process as a first stage of a two-stage combustion system for onboard processing of broadened specification fuels to improve their combustion characteristics is discussed. For the nonoptimal reactor design used, excessive catalyst bed temperatures and a propensity for solid carbon deposition in the bed were observed. These phenomena are not fully understood and need further elucidation. Thermal reactor schemes (without catalysts) may be more advantageously applied to aviation turbine engines, but these schemes also require additional investigation to delineate design requirements.

(CATALYSIS, LIFE CYCLE COSTS, TURBOJET)

H78 33009 LINEAR AEROSPIKE ENGINE STUDY FOR REUSABLE LAUNCH VEHICLES, Final Report, June 1976-April 1977

Diem, H.G., Kirby, F.M., (Rocketdyne, Canoga Park, CA), N78-11082
Avail:NTIS

Parametric data on split-combuster linear engine propulsion systems are presented for use in mixed-mode single-stage-to-orbit (SSTO) vehicle studies. Preliminary design data for two selected engine systems are included. The split combustor was investigated for mixed-mode operations with oxygen-hydrogen propellants used in the inner combustor in Mode 2, and in conjunction with either oxygen/RP-1, oxygen/RP-5, O_2/CH_4, or O_2/H_2 propellants in the outer combustor for Mode 1. Both gas generator and staged combustion power cycles were analyzed for providing power to the turbopumps of the inner and outer combustors. Numerous cooling circuits and cooling fluids (propellants) were analyzed and hydrogen was selected as the preferred coolant for both combustors and the linear aerospike nozzle. The maximum operating chamber pressure was determined to be limited by the availability of hydrogen coolant pressure drop in the coolant circuit.

(GAS GENERATORS, SPACECRAFT PROPULSION)

H78 33010 COMBUSTION IMPROVEMENT IN A HYDROGEN-FUELED ENGINE

Furuhama, S., (Musashi Inst. of Tech., Tokyo, Japan), Yamane, K., (Nissan Motor Co., Ltd., Tokyo, Japan), Yamaguchi, I., (Japan Auto. Res. Inst., Ibaraki, Japan), Int. J. Hydrogen Energy, V 2:329-340, Oct. 27, 1977, A78-16050

Experimental testing of hydrogen-fueled engines has verified that hydrogen can be used safely and easily, and is a promising fuel for automobiles. However, there are problems with abnormal combustion and NO(X) formation. This paper discusses the phenomenon of abnormal combustion and presents a correlation between the abnormal combustion and NO(X) formation. Elimination of these problems was accomplished after several engine modifications and by an experimentally developed "combined combustion process." The characteristics of a hydrogen-oxygen engine with a hydrogen-rich fuel mixture were also studied. This engine was found to have an unexpectedly narrower range of operation than a hydrogen-air engine.

(COMPRESSION TESTS, FUEL-AIR RATIO, OPTIMIZATION)

H78 33011 FLAMES OF H_2 AND O_2 PROPELLANT SYSTEM IN A MODULAR REACTOR

Guarise, F.B., Menin, G.A., Rienzi, S.A., (Padova Universita, CNR, Centro Di Studio Sulle Reazioni Alle Alte Temperature e Alle Alte Pressioni, Padua, Italy), Flames as Reactions in Flow, Universita di Padova, Padova, Italy, p. 293-298, 1977, A78-17215

The evolution of a propellant flame is mainly known by the reaction enthalpy distribution. A modular rocket combustion chamber was constructed in order to allow the measurement of both total and radiative thermal fluxes along the combustor. The radiation sensor and the experimental technique for the radiation measurement are described. The results obtained with the H_2 plus O_2 system confirm that the radiation from the flame zone is noticeably higher than that measured after this zone. Owing to the low combustion efficiency related to the particular injector geometry, the results cannot be directly compared with those obtained by Ziebland (1975); nevertheless, a certain agreement is evident.

(COMBUSTION CHAMBERS, INJECTORS, TRANSDUCERS)

H78 33012 HYDROGEN FILM COOLING OF A SMALL HYDROGEN-OXYGEN THRUST CHAMBER AND ITS EFFECT ON EROSION RATES OF VARIOUS ABLATIVE MATERIALS

Hannum, N., Roberts, W.E., Russel, L.M., (NASA, Lewis Res. Center, Cleveland,OH), NASA-TP-1098 E-3909, N78-13124
Avail:NTIS

An experimental investigation was conducted to determine what arrangement of film-coolant-injection orifices should be used to decrease the erosion rates of small, high-temperature, high-pressure ablative thrust chambers without incurring a large penalty in combustion performance. All of the film cooling was supplied through holes in a ring between the outer row of injector elements and the chamber wall. The best arrangement, which had twice the number of holes as there were outer row injection elements, was also the simplest. The performance penalties, presented as a reduction in characteristic exhaust velocity efficiency, were 0.8 and 2.8 percentage points for the 10 and 20 percent cooling flows, respectively. The best film-coolant injector was then used to obtain erosion rates for 19 ablative materials. The throat erosion rate was reduced by a factor of 2.5, with a 10 percent coolant flow. Only the more expensive silica phenolic materials had low enough erosion rates to be considered for use in the nozzle throat. However, some of the cheaper materials might qualify for use in other areas of small nozzles with large throat diameters, where the higher erosion rates are more acceptable.

(EROSION, NOZZLE WALLS, THRUST CHAMBERS)

H78 33013 CATALYTIC COMBUSTION OF PREMIXED HYDROGEN-AIR

Mori, Y., Miyauchi, T., Hirano, M., (Tokyo Inst. of Tech., Tokyo, Japan), Combustion and Flame, V 30:193-205, N2, 1977, Ministry of Education, Science, and Culture, MESC-985036, A78-13485

At temperatures of 1100 K or below (where nitrogen oxide is not produced in hydrogen-air premixed gas) experimental and theoretical investigations are carried out on the combustion on a catalytic platinum flat-plate. It is found that (1) using a platinum flat-plate as a catalyst, the low-temperature (below 1100 K) combustion of hydrogen-air premix premixed gas, having concentrations as low as 2-7 mole, is possible; (2) when the radiative effect and the concentration are considered, the surface temperature and the temperature distribution in the boundary layer are well-predicted by numerical calculations; and (3) the active points of the surface may be assumed to be heterogeneously distributed in order to explain why the mean hydrogen concentration on the surface is not zero, and to explain the thin concentration boundary layer.

(FLAT-PLATES, FUEL COMBUSTION, HYDROGEN FUELS)

H78 34011 FUEL CELL WITH HYDRONIUM BETA-ALUMINA ELECTROLYTE

Dubin, R.R., Roth, W.L., (General Electric Co., Wilmington, MA), US Patent no. 4,032,694, Filed Aug. 26, 1976, Patented June 28, 1977

Patent operation at 24° C.

(ALUMINUM OXIDES, DESIGN)

H78 34012 NEW MATERIALS FOR FLUOROSULFONIC ACID ELECTROLYTE FUEL CELLS, Final Technical Report, Oct. 7, 1974-April 7, 1977

George, M., Januszkiewicz, S., (Energy Res. Corp., Danbury, CT), 49 p., AD-A044414 ERC-0123-F, N78-12531
Avail:NTIS

Hydrogen-air fuel cells were evaluated with TFMSA monohydrate and dilute TFMSA. Pressurized monohydrate cells were run at power levels comparable to phosphoric acid fuel cells under similar conditions. Fuel cells with from 25 to 60 percent TFMSA were evaluated at 25 and 70 C. A cell with 50 percent TFSMA was run for over 2,000 hours at room temperature without acid replenishment. Power densities in excess of 130 mw/cm^2 could be achieved at ambient temperatures and pressures with low loading catalysts. The evaluation of supported platinum and tungsten carbide catalyst with dilute TFMSA was initiated. Silicon carbide was investigated as a matrix material with TFMSA.

(ELECTROCATALYSTS, SILICON CARBIDES)

H78 34013 DOPED SILVER CATALYSTS FOR H_2-AIR FUEL CELLS

Hoenne, K., (Siemens Ag, Forschungslaboratorien, Erlangen, West Germany), Siemens Forschungs und Entwicklungsberichte, V 6:350-354, N6, 1977, Res. supp. by the Bundesministerium fuer Forschung und Technologie, A78-13644

An investigation was conducted with the objective to improve a doped silver catalyst reported by Hoenne (1974). The improvement is to make it possible to employ the catalyst for a use of air in H_2-air fuel cells with an alkaline electrolyte. The considered catalyst is doped with small amounts of Bi, Ni, and Ti. The effect of the parameters of catalyst manufacturing conditions on the catalyst characteristics was studied. Attempts were made to improve the catalytic activity with mercury-containing additives. Electrodes were obtained with a composition of 76.6 percent catalyst material, 20 percent Teflon, and 3.4 percent asbestos. The electrodes were tested in fuel cells containing sedimented bonded Raney nickel electrodes as anodes. The carbon dioxide of the air used in in the experiments was removed with the aid of soda lime. It was found that the Hg-additive improves the stability of the catalyst for long-term operations.

(ADDITIVES, ELECTROCATALYSTS, ELECTRODES)

H78 34014 ALUMINUM-BASED ANODES FOR UNDERWATER FUEL CELLS

Urbach, H.B., Cervi, M.C., (David W. Taylor Naval Ships Res. and Dev. Center, Annapolis, MD), Proc. of the 12th Intersoc. Energy Conversion Engng. Conf., V 1:276-282, 8 refs, Aug. 28-Sept. 2, 1977, Am Nuclear Soc., La Grange Park, IL, IEEE, et al., Washington, D.C. Avail:IEEE

The anodic properties of various aluminum alloys are studied potentiostatically with measurement of hydrogen evolution and potential. Also, an aluminum-oxygen fuel cell is examined for its polarization behavior. The lowest rate of anodic-hydrogen evolution at any given potential is measured on high-purity aluminum, since impurities tend to increase the rate of hydrogen evolution. Temperature studies on aluminum fuel cells indicate that power efficiency drops severely over 50 C. At 50 C, power efficiencies exceeding 50 percent at a power density of 108 ma/cm^2 were obtained. At 188 and 242 ma/cm$_2$, the power efficiency dropped to 40 percent and 30 percent, respectively. Aluminum-lithium alloys coupled with sea water appear to be more desirable systems than those of pure aluminum because of their higher reactivity (power density), higher specific energy, and self-activating properties.

(ANODIC PROPERTIES, SEAWATER, SELF ACTIVATING-PROPERTIES)

40000 IV. TRANSMISSION, DISTRIBUTION, AND STORAGE

H78 40008 NEW ALLOY SYSTEMS FOR HYDROGEN STORAGE

Adkins, C.M., Taylor, E.J., (Dept. of Materials Sci., Univ. of Virginia, Charlottesville, VA), Electrochem. Soc., Spring Mtg., (Papers in extended summary form received only), p. 932-933, May 8-13, 1977, Philadelphia, PA, Electrochem. Soc., Princeton, NJ

The hydrogenation of metal alloys is studied with the assumption that the characteristics of the metal hydride are governed by the electron distributions of the parent alloy. An approach of alloy bonding theory proposed by Engel and Brewer is used and applied to the $FeTiH_2$ system.

(ALLOY BONDING THEORY, METAL HYDRIDE)

H78 40009 STORAGE AND DISTRIBUTION OF LARGE QUANTITIES OF HYDROGEN

Donat, G., (Electricite de France, Paris, France), Colonna, J., (Gaz de France, Paris, France), Int. Workshop on Hydrogen and its Perspectives Proc., Liege, Belgium, (A78-13826 06-44), V 1:19, Nov. 15-18, 1976, Assoc. des Ingenieurs Electriciens Sortis de L'Institut Electrotechnique Montefiore, 1977, A78-13838

Storage of hydrogen gas in abandoned mines and in porous or permeable caverns (including anticlines with underground aquifers) is discussed. In general, techniques applied to the storage and transport of natural gas may also be adapted to hydrogen. In addition, attention is given to the storage of liquid hydrogen, which may allow for maintenance in spherical reservoirs of the equivalent of 10 million normal m^3 of gas with daily evaporation losses of less than 0.05 percent. A comparative analysis of the costs of transporting hydrogen and natural gas through pipelines is presented.

(COST EFFECTIVENESS, GAS TRANSPORT, PIPELINES)

H78 40010 HYDROGEN CRYOGENIC STORAGE LIQUID FOR AUTOMOTIVE APPLICATIONS AND CRYADSORBENTS FOR PIPELINE DISTRIBUTION SYSTEMS

Peschka, W., Carpetis, C., (Deutsche Forschungs und Versuchsanstalt fur Luft und Raumfahrt, Cologne, West Germany), Int. Workshop on Hydrogen and its Perspectives Proc., Liege, Belgium, (A78-13826 06-44), V 1:21, Nov. 15-18, 1976, Assoc. de Ingenieurs Electriciens Sortis de L'Institut Electrotechnique Montefiore, 1977, A78-13844

The design of a compact cryogenic tank for storing the liquid hydrogen used in an automobile engine is described, and a cryogenic storage system which would employ adsorbent materials at liquid nitrogen temperatures and moderate pressures is proposed. The design of the cryogenic tank would include a metal hydride to achieve a loss-free storage period of eight to ten days. A prototype tank with a complete pressure and valve control system has been tested. Low-pressure cryogenic storage facilities making use of such adsorbents as activated charcoal or nickel-silicate compounds are also mentioned. If regenerative heat recovery is introduced into the system, the cryoadsorbents may offer a more efficient means of storage than conventional liquid hydrogen tanks.

(ADSORPTION, AUTOMOBILE ENGINES, LIQUID HYDROGEN)

H78 40011 TECHNOLOGICAL DATA BASES FOR ENERGY STORAGE

Quick, T.M., (California Univ., Lawrence Livermore Lab., Livermore, CA), (ERDA), 11 p., Sept. 23, 1977, GRAI7807, Rept. no. CONF-770955-1, contract no. W-7405-ENG-48, ERDA Info. Exchange Mtg. for Thermal Energy Storage Program, Gatlinburg, TN, Sept. 29, 1977 Avail:NTIS

The Data Management Group at the Lawrence Livermore Laboratory is conducting research leading to the creation of data bases for energy storage systems. These data bases are computer-based and will contain bibliographic information, material properties data, and data on essential criteria for energy storage systems. Access to these central files will be from remote terminals over computer networks and by telephone dial-up, in addition to the more conventional means of computer-generated reporting, and dissimination on magnetic tape. To validate the material properties data, a working agreement has been established between the Lawrence Livermore Laboratory (LLL) and the National Bureau of Standards (NBS). The Office of Standard Reference Data at NBS coordinates and monitors data evaluations by recognized data evaluation centers.

(COMPUTERS, ELECTRIC BATTERIES, HEAT STORAGE)

H78 40012 EXOTIC POWER AND ENERGY STORAGE

Surface, M.O., Power Engng., Barrington, IL, V 81:36-44, N12, Dec. 1977, ID no. EI780424759
Avail:Engng. Index

Because of growing fuel shortages and environmental requirements, there is increasing emphasis on finding alternatives to fossil fuels for power generation, and to improving the load factor of the most efficient base load units, either by controlling demand, or by employing some type of energy storage. Technically feasible near-terstorage systems include conventional and underground hydro-pumped storage, compressed-air storage for combustion turbines, thermal energy storage in central power plants, and the lead-acid battery. Possible intermediate-term (1985-2000) storage systems for utility use include advanced batteries, flywheels, and hydrogen. One long-term storage system, which could become competitive is a concept of direct electrical storage in superconducting magnets. Such a system would consist of a large magnet in a solenoidal or toroidal configuration, which would be cooled to temperatures where the superconducting affects would occur. Power supplied to the coil during charging would have to be converted to direct current, and power supplied by the storage system during peak load would require inversion to alternating current. The losses of such a system would be those associated with the cryogenic cooling and the inverter-converter system.

(ELECTRIC POWER GENERATION)

H78 40105 STUDY OF THE POTENTIAL FOR IMPROVING THE ECONOMICS OF HYDROGEN LIQUEFACTION THROUGH THE USE OF CENTRIFUGAL COMPRESSORS AND THE ADDITION OF A HEAVY WATER PLANT

Baker, C.R., (Union Carbide Corp., Tonawanda, NY, Linde Div.), NASA-CR-145282, 145 p., N78-15564
Avail:NTIS

An approach to the liquefaction of hydrogen was developed, which permits the application of standard centrifugal compressors in place of reciprocating machines. A second fluid, such as propane, is added to the hydrogen prior to compression to form a mixture having a molecular weight much greater than that of hydrogen alone, so that a standard centrifugal compressor can be used. After compression, the mixture is cooled to cryogenic temperature levels where the propane condenses out of the mixture and is separated as a liquid. Since a small amount of deuterium is produced during hydrogen liquefaction, the potential of recovering deuterium and selling it as a co-product was investigated. Deuterium, in the form of heavy water, can be used in certain nuclear reactors as a neutron moderator to reduce the neutron velocity and enhance the probability of neutron collision with uranium nuclei.

(JET ENGINE FUELS, LIQUID HYDROGEN)

H78 40106 STUDIES OF HYDROGEN LIQUEFIER EFFICIENCY AND THE RECOVERY OF THE LIQUEFACTION ENERGY

Voth, R.O., Parrish, W.R., (NBS, Boulder, CO, Cryogenics Div.), 63 p., Aug. 1977, GRAI7802, rept. no. NBSIR-77-862, project no. NBS-2750153
Avail:NTIS

Liquid hydrogen is a potential synthetic fuel. It is nonfossil, its production and storage technology is well developed, and it is inherently nonpolluting. However, the economics of liquefying hydrogen are costly both in the energy required to produce the liquid and in the capital costs of the liquefier. These costs could be reduced by increasing the liquefier efficiency and/or by recovering a portion of the liquefaction energy at the use site. This paper provides the maximum hydrogen liquefier efficiency based on the efficiency of available components and the fraction of original liquefaction energy that can be recovered at the use site. Since the inefficient compressors and expanders are the major cause of liquefier inefficiency, no increase in liquefier efficiency above the current 30-35 percent is probable without a corresponding increase in compressor and expander efficiency, a difficult task since both the compressors and expanders have a long and stable history of development. However, roughly one-third to one-half of the actual energy required to liquefy hydrogen can be recovered at the use site and this represents a cost credit for liquid hydrogen.

(CRYOGENICS, FUELS, LIQUID HYDROGEN)

H78 40201 THE ROLE OF TRAPPING ON HYDROGEN TRANSPORT AND EMBRITTLEMENT, Ph.D. Thesis

Pressouyre, G.M., (Carnegie-Mellon Univ., Pittsburgh, PA), 232 p., N78-13175
Avail:Univ. Microfilms order no. 77-27724

Alloys of Fe-Ti in both the carburized and uncarburized condition were chosen as the model material to simulate internal trapping of hydrogen. Microstructure characterization revealed that all alloys consisted of a ferrite matrix, in which free substitutional titanium atoms and titanium carbide particles were present. Techniques were developed to distinguish between reversible traps. A classification of the traps in terms of strength, density, occupancy, and reversible character was then obtained. Based upon the results of trap characterization, hydrogen embrittlement of Fe-Ti alloys was then examined. The kinetics and extent of static hydrogen embrittlement was both theoretically modelled and experimentally investigated. The best alloys were those with a fine distribution of irreversible TiC particles. A qualitative model was proposed to explain the reasons for this. Lastly, sets of criteria were proposed for the design of alloys that would resist both static and dynamic hydrogen embrittlement.

(ALLOYS, MICROSTRUCTURE, TITANIUM CARBIDES)

H78 40302 THIN FILM ATOMIC HYDROGEN DETECTORS

Gruber, C.L., (S. Dakota School of Mines and Tech., Dept. of Engng., Rapid City, SD), NASA-CR-152605, NAS5-23470, 33 p., June 1977, STAR1524
Avail:NTIS

Thin film and bead thermistor atomic surface recombination hydrogen detectors were investigated both experimentally and theoretically. Devices were constructed on a thin Mylar film substrate. Using suitable Wheatstone bridge techniques, sensitivities of 80 mv/2 x 10^{13} atoms/sec are attainable with response time constants on the order of five seconds.

(MEASURING INSTRUMENT, SENSITIVITY)

H78 40603 THE HYDROGEN PIPELINE NETWORK IN THE RHINE-RUHR AREA

Isting, C., (Chemische Werke Huls Ag, Marl, West Germany), Int. Workshop on Hydrogen and its Perspectives Proc., Liege, Belgium, (A78-18826 06-44), V 1:22, Nov. 15-18, 1976, Assoc. des Ingenieurs Electriciens Sortis de L'Institut Electrotechnique Montefiore, 1977, A78-18837

A hydrogen distribution system, which includes 875 km of pipeline between 25 chemical and petrochemical plants in the Rhine-Ruhr area, is described. The hydrogen is produced by partial oxidation, electrolysis of water, catalytic cracking of methane, or coal gasification. It is used to manufacture such products as ammonia, fuel gas, and methanol. Venting techniques to prevent explosions, leakage testing, insulation for the pipelines, the automatic line rupture shutoff valves, hydrogen diffusion into the grain boundaries of the pipe materials, government regulation of the distribution network, and the central control facility of the pipeline network are considered.

(ENERGY TECHNOLOGY, SAFETY FACTORS)

H78 43005 METAL HYDRIDE STORAGE FOR HYDROGEN-FUELED GROUND VEHICLES

Brooman, E.W., Allen, C.M., (Battelle Columbus Lab., Columbus, OH), Metall. Mater. Tech., V 9:263-268, N5, May 1977

No abstract available

(BUSES, CRYOGENICS, FLUIDIZED BED)

H78 43006 HYDROGEN-IN-METALS CONFERENCE

Cathey, W.N., (Office of Naval Res., London, England), Conf. held at Paris, June 1977, 12 p., AD-A046019 ONRL-C-7-77, N78-14147
Avail:NTIS

This report presents a review of a few important papers. Most of the papers were related to applied problems. In particular, problems of H-related damage to engineering alloys were treated extensively. In addition to work on H in pure metals, such as Pd, Nb, and other transition metals, some work was also reported on H in alloys such as Nb-Ti, Pd-Ag, and various steels. Storage of H in intermetallic compounds, such as $FeTiH_x$ or $LaNi_5H_x$ was of great interest because of their importance as energy converters.

(HYDROGEN EMBRITTLEMENT, INTERMETALLICS)

H78 43007 THE STORAGE OF HYDROGEN IN THE FORM OF METAL HYDRIDES: AN APPLICATION TO THERMAL ENGINES

Gales, C., Perroud, P., (Commissariat a L'Energie Atomique, Centre D'Etudes Nucleaires de Grenoble, Grenoble, France), Int. Workshop on Hydrogen and its Perspectives Proc., Liege, Belgium, (A78-13826 06-44), V 1:34, Nov. 15-18, 1976, Assoc. des Ingenieurs Electriciens Sortis de L'Institut Electrotechnique Montefiore, 1977, In French, A78-13845

The possibility of using $LaNi_5H_6$, $FeTiH_2$, or MgH_2 as metal hydride storage systems for hydrogen-fueled automobile engines is discussed. A study of magnesium-copper and magnesium-nickel hydrides indicates that they provide more stable storage systems than pure magnesium hydrides. Several test engines employing hydrogen fuel have been developed a single-cylinder motor, originally designed for use with air-gasoline mixtures; a four-cylinder engine, modified to run on an air-hydrogen mixture; and a gas turbine.

(AUTOMOBILE FUELS, HYDROGEN ENGINES)

H78 43008 PREPARATION, CHARACTERIZATION, AND USE OF METAL HYDRIDES FOR FUEL SYSTEMS, Progress Report, Sept. 1, 1976-May 31, 1977

Herley, P.J., (State Univ. of NY at Stony Brook, Dept. of Materials, Stony Brook, NY), 80 p., May 1977, contract no. EY-76-S-02-2715
Avail:NTIS

The isothermal decomposition kinetics of unirradiated andirradiated powdered lithium aluminum hydride have been determined in the temperature range 125-155 C. The resulting activation energies for unirradiated material for the induction, acceleratory, decay, and slow final rate were, respectively, 116.3, 94.3, 87.1, and 12.9 $\pm$ 4.6 kj/mole. For preirradiated powders (1.25 x 10^5 rad), activation energies for the same periods were 119.0, 99.5, 80.5, and 10.0 $\pm$ 4.6 kj/mole, respectively. Admixture with powdered aluminum, nickel, and final reaction product did not affect the subsequent thermal decomposition. Exposure to dry air and carbon dioxide do not affect the decomposition, but two-minute exposure to saturated water vapor reduces the percentage decomposition by almost 50 percent.

(HYDROGEN STORAGE, PYROLYSIS, RADIATION EFFECTS)

H78 43009 APPLICATIONS OF METAL HYDRIDES

Reilly, J.J., (Brookhaven Nat'l Lab., Upton, NY), rept. no. CONF-770823-2, contract no. EY-76-C-02-0016, 38 p., Aug. 1977, Int. Symp. on Hydrides for Energy Storage, Geilo, Norway, Aug. 14, 1977, GRAI7807
Avail:NTIS

The practical application of metal hydrides is discussed with primary emphasis on their use as energy storage media. Specific applications include automotive, utility load leveling, thermal storage, and hydride compressors.

(COMPRESSORS, HYDROGEN STORAGE, PUBLIC UTILITIES)

H78 43010 A NEW FAMILY OF HYDROGEN STORAGE ALLOYS BASED ON THE SYSTEM NICKEL-MISCHMETAL-CALCIUM

Sandrock, G.D., (Paul D. Merica Res. Lab., Int. Nickel Co., Inc., Sterling Forest, Suffern, NY), Proc. of the 12th Intersoc. Energy Conversion Engng. Conf., V 1:951-958, 19 refs, Aug. 28-Sept. 2, 1977, Am. Nuclear Soc., La Grange Park, IL, IEEE, et al., Washington, D.C.
Avail:IEEE

A new family of low-cost Ab_5H storage compounds based on the formula $Ca_xM_{1-x}Ni_5$ has been developed. M is the standard rare earth alloy mischmetal and x can be varied from 0 to 1. The basic properties are presented as a function of x, including pressure-temperature-composition relations, ease of activation, heats of reaction, relative materials cost, melting, and other metallurgical considerations, and crystal structure correlations.

(CALCIUM COMPOUNDS, RARE EARTH)

H78 43011 SOME RATE AND MODELING STUDIES ON THE USE OF IRON-TITANIUM HYDRIDE AS AN ENERGY STORAGE MEDIUM FOR ELECTRIC UTILITY COMPANIES

Strickland, G., Yu, W.S., (Brookhaven Nat'l Lab., Upton, NY), contract no. EY-76-C-02-0026, 62 p., April 26, 1977, GRAI7807
Avail:NTIS

Dynamic tests and modeling studies were made on the chemical-energy-storage portion of an electrical energy conversion and storage system proposed for leveling the load of an electric utility company. The concept utilizes off-peak power to produce hydrogen by electrolyzing water, storing the hydrogen as iron-titanium hydride, $FeTiH_x$, and subsequently, releasing the hydrogen to a fuel cell, where the reaction with air generates electrical power. The hydrogen storage portion of the system was tested on a small scale, using a six-inch-diameter by 30-inch-long test bed, containing 84 lb of FeTi alloy. Hydrogen reacts with this alloy at ordinary temperatures, with the release of heat, producing the hydride $FeTiH_x$, and hydrogen is released by heating the hydride to decompose it. In the six hydriding-dehydriding cycles that were studied, the times that hydrogen flow rates of 40 to 10 standard liters per minute (SLPM) could be sustained were determined.

(HYDROGEN PRODUCTION, OFF-PEAK ENERGY)

50000 V. SAFETY

H78 50003 SAFETY PROBLEMS IN THE USE OF LIQUID HYDROGEN

Faure, A., (L'Air Liquide, Paris, France), Int. Workshop on Hydrogen and its Perspectives Proc., Liege, Belgium, (A78-18826 06-44), V 2:24, Nov. 15-18, 1976, Assoc. des Ingenieurs Electriciens Sortis de L'Institut Electrotechnique Montefiore, 1977, In French, A78-18858

Cryogenic and combustion hazards associated with the use of liquid hydrogen are examined. Cryogenic hazards include contamination by condensed air, excessive pressures, damage to exposed materials, and human tissue destruction. Procedures are considered for avoiding the formation of flammable mixtures in liquid hydrogen containers, or in the atmosphere, and for avoiding ignition sources. Safety features for storage sites and methods of fighting hydrogen fires are discussed.

(BIOLOGICAL EFFECTS, HAZARDS, LEAKAGE)

H78 50004 POLLUTION CONTROL IN GEOTHERMAL ENERGY

Hartley, R.P., (Industrial Environmental Res. Lab., US Environmental Protection Agency, Cincinnatti, OH), Proc. of the 12th Intersoc. Energy Conversion Engng. Conf., V 1:607-613, 11 refs, Aug. 28-Sept. 2, 1977, Am. Nuclear Soc., La Grange Park, IL, IEEE, et al., Washington, D.C.
Avail:IEEE

Pollution problems occur in geothermal energy development because large volumes of spent geothermal fluid being released, potentially contaminate the air, surface waters, and ground waters. Waters may be highly saline and contain metals in hazardous concentrations. Noncondensible gases are of greatest concern in air discharges. The principal anticipated liquid disposal method is reinjection to the producing reservoir, for which reliable technologies must be developed. Water treatment for surface discharge could be possible, but costly, although minerals recovery might be offsetting in some cases. The principal air pollutant of concern is hydrogen sulfide, although such constituents as ammonia, radon, and mercury may also be significant. Considerable development and demonstration is under way for hydrogen sulfide removal, resource characterization data are not yet sufficient to predict the full range of potential pollution problems, particularly for the widespread and variable liquid-dominated resource.

(DETECTION AND CONTROL, SURFACE WATERS)

H78 50005 SAFETY TECHNIQUE ASPECTS OF HYDROGEN TECHNOLOGY

Pennings, P., (Tuv Rheinland, Koeln, Germany), Gas Wasserfach, Gas-Erdgas, V 118:230-235, N6, June 1977, In German

No abstract available

(INDUSTRIAL PLANTS, PRODUCTION, STORAGE)

H78 50006 DEVELOPMENT STATUS AND ENVIRONMENTAL HAZARDS OF SEVERAL CANDIDATE ADVANCED ENERGY SYSTEMS

Penny, M.M., Bourgeois, S.V., Cain, W.C., (Lockheed-Huntsville Res. and Engng. Center, Huntsville, AL), Proc. of the 12th Intersoc. Energy Conversion Engng. Conf., V 1:646-664, 25 refs, Aug. 28-Sept. 2, 1977, Am. Nuclear Soc., La Grange Park, IL, IEEE, et al., Washington, D.C.

This paper reviews the development status and anticipated primary environmental hazards of the following advanced energy systems ocean thermal energy conversion (OTEC), wind power, magnetohydrodynamics (MHD), hydrogen fuel cells, potassium topping cycles, high-temperature turbines, thermionic, thermoelectric, and electrogasdynamic systems.

(HYDROGEN FUEL CELLS, WIND POWER)

H78 52005 MATERIALS PROBLEMS IN HYDROGEN ENERGY SYSTEMS

Syrett, B.C., Jones, R.L., Daniels, N.H.G., (Stanford Res. Inst., Menlo Park, CA), Int. Workshop on Hydrogen and its Perspectives Proc., Liege, Belgium, (A78-18826 06-44), V 1:12, Nov. 15-18, 1976, Assoc. des Ingenieurs Electriciens Sortis de L'Institut Electrotechnique Montefiore, 1977, A78-18839

Research in support of a large-scale hydrogen fuel production system projected for implementation in the US by 2020 is described. Improvements in corrosion-resistant materials for anodes, the development of separator materials with high conductivity and good performance to about 200 C, and the development of inexpensive polymers for cell frames are discussed. In addition, the need for gas diffusion electrode structures with high-effective electrode areas, as well as active nonnoble electrocatalysts for both the anode and cathode, is mentioned. For solid polymer electrolyzers, inexpensive ion-conducting membranes with high ionic conductivity and temperature resistance are required.

(ELECTROCATALYSTS, ELECTRODES, PRODUCTION)

H78 52006 SCIENCE MATERIALS FOR THE DEVELOPMENT OF ENERGY CONVERSION AND STORAGE DEVICES, Progress Report, July 1, 1976-June 30, 1977

(Illinois Univ., Urbana-Champaign, IL, Materials Res. Lab.), 160 p., COO-1198-1181, N78-15176
Avail:NTIS

The mechanical properties of metals and alloys, fracture, corrosion of metals, the defect and catalytic properties of oxides, and the structure of polymers and liquids were investigated. Emphasis was placed on the role of light interstitial alloying agents in affacting mechanical properties of metals with particular attention to hydrogen as an embrittlement agent. Electronic properties of phosphors, semiconductors, dichalcogenide layer compounds, hydrocarbon catalysts, and magnetic impurities were examined. Crystalline defects were studied in detail. Dislocation mechanisms of plastic flow were investigated and point defect studies included idffusion in refractory metals and quantum effects on vacancy migration in helium crystals. Of special interest were the defect structures conductive to fast ion motion in supersonic crystals and the roles of covalent binding and defects in determining the hardness of the transition metal carbide compounds.

(ALLOYS, CORROSION PREVENTION, HYDROGEN EMBRITTLEMENT)

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FER, PNEUM/ COAL, CONVERSION,	CHEMICAL-REACTIONS, HEAT-TRANS	022018
REPARATION, CADMIUM, THERMOC/	CHEMICAL-REACTIONS, PROCESS, P	010021
ED# COAL-CHAR, ELECTROFLUID,	CHEMICAL-REACTORS, FLUIDIZED-B	022015
IDATION-PROCE/ SYNTHESIS-GAS,	CHEMICAL-REACTORS, NOZZLES, OX	023204
IFICATION, WASTE-UTILIZATION/	CHEMICALS, CROPS, BIOMASS, GAS	023201
ONDENSABLE-PRODUCTS, SOLUTION	CHEMISTRY, WATER-DECOMPOSITION	021006
CAL-REACTORS, FLUIDIZED-BED#	COAL-CHAR, ELECTROFLUID, CHEMI	022015
COAL, LIQUEFACTION,	COAL-FINES, MATERIALS-TESTING#	022017
AMMONIA, NITROGEN, CATALYST,	COAL-GASIFICATION PLANTS, IRON	021015
AIR/ PERSPECTIVES, CRACKING,	COAL-GASIFICATION, TOXICOLOGY,	010037
TOMOTIVE, LIQUID, EFFICIENCY,	COAL-LIQUEFACTION# /OBILES, AU	010033
, COAL, CHEMICAL-COMPOSITION,	COAL-PREPARATION, FLOW SHEETS#	022014
AL-PREPARATION, / CONVERSION,	COAL, CHEMICAL-COMPOSITION, CO	022014
CTIONS, HEAT-TRANSFER, PNEUM/	COAL, CONVERSION, CHEMICAL-REA	022018
IFICATION# CONVERSION,	COAL, FEASIBILITY-STUDIES, GAS	022016
, MATERIALS-TESTING#	COAL, LIQUEFACTION, COAL-FINES	022017
, TRANSD/ FLAMES, PROPELLANT,	COMBUSTION CHAMBERS, INJECTORS	033011
ES, REVIEW, AUTOMOTIVE-FUELS,	COMBUSTION PROPERTIES# /RNATIV	010023
FUEL-AIR RATIO, OPTIMIZATIO/	COMBUSTION, COMPRESSION TESTS,	033010
COMBUSTION, HYDRO/ CATALYTIC,	COMBUSTION, FLAT-PLATES, FUEL-	033013
EW, ECONOMICS, ELECTROLYSIS#	COMMERCIAL, PRODUCTION, OVERVI	010020
ION-BASED, STORAGE, BREEDING,	COMMERCIALIZATION, HYBRID-REAC	010026
NOMIC-FACTO/ LIQUID-HYDROGEN,	COMPARISON, COST-ANALYSIS, ECO	010027
TIO, OPTIMIZATIO/ COMBUSTION,	COMPRESSION TESTS, FUEL-AIR RA	033010
NG# DESIGN, CONSERVAITON,	COMPRESSORS, COST, HYDROCRACKI	010031
APPLICATIONS, METAL-HYDRIDES,	COMPRESSORS, HYDROGEN STORAGE,	043009
LIQUID-HYDROGEN# ECONOMICS,	COMPRESSORS, JET-ENGINE-FUELS,	040105
HEAT-S/ DATA-BASES, STORAGE,	COMPUTERS, ELECTRIC-BATTERIES,	040011
, THERMOCHEMICAL, PRODUCTION,	CONDENSABLE-PRODUCTS, SOLUTION	021006
MBRITTLEMENT, INTERMETALLICS/	CONFERENCE, REVIEW, HYDROGEN E	043006
T, HYDROCRACKING# DESIGN,	CONSERVAITON, COMPRESSORS, COS	010031
INTERNATIONAL, DISTRIBUTION,	CONSERVATION, RESOURCES, STORA	010019
, HEAT-TRANSFER, PNEUM/ COAL,	CONVERSION, CHEMICAL-REACTIONS	022018

POSITION, COAL-PREPARATION, /	CONVERSION, COAL, CHEMICAL-COM	022014
STUDIES, GASIFICATION#	CONVERSION, COAL, FEASIBILITY-	022016
HERM/ INDUSTRIAL, PRODUCTION,	COPPER-CHLORIDES, PYROLYSIS, T	021014
MATERIALS, STORAGE, ALLOYS,	CORROSION-PREVENTION, HYDROGEN	052006
LIQUID-HYDROGEN, COMPARISON,	COST-ANALYSIS, ECONOMIC-FACTOR	010027
N, EFFICIENCY, SULFURIC-ACID,	COST-EFFECTIVENESS, IRREVERSIB	021009
GAS-/ STORAGE, DISTRIBUTION,	COST-EFFECTIVENESS, PIPELINES,	040009
, THERMOCHEMICAL, PRODUCTION,	COST, EFFICIENCY, PRODUCTION#	021012
N, CONSERVAITON, COMPRESSORS,	COST, HYDROCRACKING# DESIG	010031
OXICOLOGY, AIR/ PERSPECTIVES,	CRACKING, COAL-GASIFICATION, T	010037
WASTE-UTILIZATION/ CHEMICALS,	CROPS, BIOMASS, GASIFICATION,	023201
EMENT, HYD/ FUTURE, AIRCRAFT,	CRYOGENIC STORAGE, HEAT-MEASUR	030009
ION, AUTOMOBILE-ENGINES, LIQ/	CRYOGENIC, AUTOMOTIVE, ADSORPT	040010
DE, STORAGE, VEHICLES, BUSES,	CRYOGENICS, FLUIDIZED-BED# /RI	043005
OG/ EFFICIENCY, LIQUEFACTION,	CRYOGENICS, FUELS, LIQUID-HYDR	040106
TROLYSIS, ALKALINE-SOLUTIONS,	CURRENT-DENSITY, PRESSURE-EFFE	020009
, ELECTRIC-BATTERIES, HEAT-S/	DATA-BASES, STORAGE, COMPUTERS	040011
TION, THERMODYNAMIC-E/ SOLAR,	DECOMPOSITION, HYDROGEN PRODUC	023606
PRODUCTION, THERMOCHEMICAL,	DECOMPOSITION, IRON-HYDROXIDES	021019
, STORAGE# FUTURE, STATUS,	DECOMPOSITION, NICKEL-HYDRIDES	010022
ORS, COST, HYDROCRACKING#	DESIGN, CONSERVAITON, COMPRESS	010031
ICAL, ENERGY-TECHNOLOGY, SUL/	DESIGN, EVALUATION, THERMOCHEM	021008
TION, COST, EFFICIENCY, PROD/	DESIGN, THERMOCHEMICAL, PRODUC	021012
ICS, ZINC-SELENI/ FLOW-SHEET,	DESIGN, THERMOCHEMICAL, ECONOM	021011
ELECTROLYTE, ALUMINUM-OXIDES,	DESIGN# FUEL-CELL,	034011
-WATE/ POLLUTION, GEOTHERMAL,	DETECTION-AND-CONTROL, SURFACE	050004
T, SENSITIVITY# THIN-FILM,	DETECTORS, MEASURING-INSTRUMEN	040302
	'DEVELOPMEN' NOT INDEXED	
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SS, PIPELINES, GAS-/ STORAGE,	DISTRIBUTION, COST-EFFECTIVENE	040009
ETHERLANDS, FOSSIL, SCENARIO,	DISTRIBUTION, ELECTROLYSIS, EN	010038
CARRIER, REVIEW, HOUSEHOLD,	DISTRIBUTION, FUEL, STORAGE#	010036
LOYS, CALCIUM-COMPOUNDS, RARE	EARTH# STORAGE, AL	043010
N, COMPARISON, COST-ANALYSIS,	ECONOMIC-FACTORS# /UID-HYDROGE	010027
, ECONOMY, CHEMIC/ TECHNIQUE,	ECONOMIC, PROBLEMS, APPLIANCES	010024
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GINE-FUELS, LIQUID-HYDROGEN#	ECONOMICS, COMPRESSORS, JET-EN	040105
ION, PROCESS, THERMOCHEMICAL,	ECONOMICS, ELECTROLYSIS, RESEA	010028
ERCIAL, PRODUCTION, OVERVIEW,	ECONOMICS, ELECTROLYSIS# COMM	010020
S, / EVALUATION, NATURAL-GAS,	ECONOMICS, FINANCIAL-INCENTIVE	010040
ER, ALTERNATIVE, LARGE-SCALE,	ECONOMICS, RESOURCES, SOLAR-PO	010029
HEET, DESIGN, THERMOCHEMICAL,	ECONOMICS, ZINC-SELENIDES# /-S	021011
ONOMIC, PROBLEMS, APPLIANCES,	ECONOMY, CHEMICAL-FEEDSTOCKS#	010024
STORAGE, PYROLYSIS, RADIATION	EFFECTS# /-HYDRIDES, HYDROGEN	043008
, ELECTROLYSIS, ENVIRONMENTAL	EFFECTS# /ENARIO, DISTRIBUTION	010038
IS, ELECTROLYTE, DEVELOPMENT,	EFFICIENCIES# ELECTROLYS	020008
OMOBILES, AUTOMOTIVE, LIQUID,	EFFICIENCY, COAL-LIQUEFACTION#	010033
GENICS, FUELS, LIQUID-HYDROG/	EFFICIENCY, LIQUEFACTION, CRYO	040106
UCTION, PHOTOELECTROCHEMICAL,	EFFICIENCY, PHOTOCHEMISTRY, TI	020006
MOCHEMICAL, PRODUCTION, COST,	EFFICIENCY, PRODUCTION# / THER	021012
THERMOCHEMICAL, PRODUCTION,	EFFICIENCY, SULFURIC-ACID, COS	021009
NONFOSSIL, THERMAL	EFFICIENCY, THREE-STEP#	021018
TA-BASES, STORAGE, COMPUTERS,	ELECTRIC-BATTERIES, HEAT-STORA	040011

IRONMENTAL# STORAGE,	ELECTRIC-POWER-GENERATION, ENV	040012
PRODUCTION# MATERIALS,	ELECTROCATALYSTS, ELECTRODES,	052005
FLUOROSULFONIC, ELECTROLYTE,	ELECTROCATALYSTS, SILICON CARB	034012
CELLS, ADDITIVES, ELECTRODES,	ELECTROCATALYSTS# /YSTS, FUEL-	034013
CKEL-CADMIUM BATTERIES, SPAC/	ELECTROCHEMICAL, UTILITIES, NI	020007
LYSTS, FUEL-CELLS, ADDITIVES,	ELECTRODES, ELECTROCATALYSTS#	034013
MATERIALS, ELECTROCATALYSTS,	ELECTRODES, PRODUCTION#	052005
S, FLUIDIZED-BED# COAL-CHAR,	ELECTROFLUID, CHEMICAL-REACTOR	022015
NS, CURRENT-DENSITY, PRESSUR/	ELECTROLYSIS, ALKALINE-SOLUTIO	020009
ELOPMENT, EFFICIENCIES#	ELECTROLYSIS, ELECTROLYTE, DEV	020008
SSIL, SCENARIO, DISTRIBUTION,	ELECTROLYSIS, ENVIRONMENTAL EF	010038
AR-ENERGY# POWER-SYSTEMS,	ELECTROLYSIS, EVAPORATION, SOL	010032
NNING REVI/ NUCLEAR-REACTORS,	ELECTROLYSIS, FORECASTING, PLA	020504
S, THERMOCHEMICAL, ECONOMICS,	ELECTROLYSIS, RESEARCH-PROGRAM	010028
DUCTION, OVERVIEW, ECONOMICS,	ELECTROLYSIS# COMMERCIAL, PRO	010020
LOADS, BOILERS, GAS-TURBINES,	ELECTROLYSIS# /R-PLANTS, PEAK-	010034
DESIGN# FUEL-CELL,	ELECTROLYTE, ALUMINUM-OXIDES,	034011
CIENCIES# ELECTROLYSIS,	ELECTROLYTE, DEVELOPMENT, EFFI	020008
SILICON CAR/ FLUOROSULFONIC,	ELECTROLYTE, ELECTROCATALYSTS,	034012
S, IRON-CHLORIDES, TRANSITION	ELEMENT# /ERMOCHEMICAL, HALIDE	021010
RUCTURE, TITANIUM-/ TRAPPING,	EMBRITTLEMENT, ALLOYS, MICROST	040301
CONFERENCE, REVIEW, HYDROGEN	EMBRITTLEMENT, INTERMETALLICS#	043006
ORROSION-PREVENTION, HYDROGEN	EMBRITTLEMENT# /AGE, ALLOYS, C	052006
GENERATOR,	ENERGY-CONVERSION, PRODUCTION#	023610
, PHOTOSYNTHESIS, REV/ SOLAR,	ENERGY-OPTIONS, HYDROGEN FUELS	010018
R, GEOTHERMAL, HYDROELECTRIC,	ENERGY-RESOURCES, GENERATION#	010025
EW, HYDROGEN, PRODU/ CARRIER,	ENERGY-RESOURCES, GENERAL REVI	010035
, EVALUATION, THERMOCHEMICAL,	ENERGY-TECHNOLOGY, SULFURIC-AC	021008
ORS# PIPELINE, RHINE-RUHR,	ENERGY-TECHNOLOGY, SAFETY-FACT	040603
, TOXICOLOGY, AIRCRAFT-FUELS,	ENERGY-TECHNOLOGY# /SIFICATION	010037
PRODUCTION, MAGMA, GEOTHERMAL	ENERGY, ROCK-FLUID-INTERACTION	023004
HYDROGEN PRODUCTION, OFF-PEAK	ENERGY# HYDRIDE, STORAGE,	043011
E, AUTOMOBILE-FUELS, HYDROGEN	ENGINES# /TAL-HYDRIDES, STORAG	043007
, DISTRIBUTION, ELECTROLYSIS,	ENVIRONMENTAL EFFECTS# /ENARIO	010038
EN FUEL-CELLS, WIND-POWER#	ENVIRONMENTAL, HAZARDS, HYDROG	050006
E, ELECTRIC-POWER-GENERATION,	ENVIRONMENTAL# STORAG	040012
TION, THEORETICAL# WATER,	EQUILIBRIUM-COMPONENTS, PRODUC	023608
CHAMBERS# THRUST,	EROSION, NOZZLE-WALLS, THRUST-	033012
MICS, FINANCIAL-INCENTIVES, /	EVALUATION, NATURAL-GAS, ECONO	010040
ERGY-TECHNOLOGY, SUL/ DESIGN,	EVALUATION, THERMOCHEMICAL, EN	021008
RAGE, BREEDING, COMMERCIALIZ/	EVALUATIONS, FUSION-BASED, STO	010026
POWER-SYSTEMS, ELECTROLYSIS,	EVAPORATION, SOLAR-ENERGY#	010032
ION# CONVERSION, COAL,	FEASIBILITY-STUDIES, GASIFICAT	022016
CTION, PHOTOSYNTHETIC, ALGAE,	FERMENTATION, MICROALGAE# /ODU	023206
TION, NATURAL-GAS, ECONOMICS,	FINANCIAL-INCENTIVES, PRODUCTI	010040
CHAMBERS, INJECTORS, TRANSD/	FLAMES, PROPELLANT, COMBUSTION	033011
HYDRO/ CATALYTIC, COMBUSTION,	FLAT-PLATES, FUEL-COMBUSTION,	033013
OMPOSITION, COAL-PREPARATION,	FLOW SHEETS# /COAL, CHEMICAL-C	022014
ICAL, ECONOMICS, ZINC-SELENI/	FLOW-SHEET, DESIGN, THERMOCHEM	021011
CTROFLUID, CHEMICAL-REACTORS,	FLUIDIZED-BED# COAL-CHAR, ELE	022015
VEHICLES, BUSES, CRYOGENICS,	FLUIDIZED-BED# /RIDE, STORAGE,	043005
LECTROCATALYSTS, SILICON CAR/	FLUOROSULFONIC, ELECTROLYTE, E	034012
CLEAR-REACTORS, ELECTROLYSIS,	FORECASTING, PLANNING REVIEW#	020504

OMERATION, CHEMICAL-ANALYSIS,	FORECASTING# /S, PHENOLS, AGGL	010039
, ELECTROLYSIS,/ NETHERLANDS,	FOSSIL, SCENARIO, DISTRIBUTION	010038
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UM-OXIDES, DESIGN#	FUEL-CELL, ELECTROLYTE, ALUMIN	034011
DES, ELECTROCATAL/ CATALYSTS,	FUEL-CELLS, ADDITIVES, ELECTRO	034013
SEAWATER, SELF ACTI/ ANODES,	FUEL-CELLS, ANODIC-PROPERTIES,	034014
IRONMENTAL, HAZARDS, HYDROGEN	FUEL-CELLS, WIND-POWER# ENV	050006
TIC, COMBUSTION, FLAT-PLATES,	FUEL-COMBUSTION, HYDROGEN FUEL	033013
IEW, HOUSEHOLD, DISTRIBUTION,	FUEL, STORAGE# CARRIER, REV	010036
CY, LIQUEFACTION, CRYOGENICS,	FUELS, LIQUID-HYDROGEN# /ICIEN	040106
LAR, ENERGY-OPTIONS, HYDROGEN	FUELS, PHOTOSYNTHESIS, REVIEWS	010018
ES, FUEL-COMBUSTION, HYDROGEN	FUELS# / COMBUSTION, FLAT-PLAT	033013
G, COMMERCIALIZ/ EVALUATIONS,	FUSION-BASED, STORAGE, BREEDIN	010026
ORAGE, HEAT-MEASUREMENT, HYD/	FUTURE, AIRCRAFT, CRYOGENIC ST	030009
PERTIES, POWER-EFFICIENCY, S/	FUTURE, AVIATION, CHEMICAL-PRO	030007
NICKEL-HYDRIDES, STORAGE#	FUTURE, STATUS, DECOMPOSITION,	010022
ESS/ PRODUCTION, UTILIZATION,	GAS-COOLED, HYDROCARBONS, PROC	020503
PULSION/ AEROSPIKE, VEHICLES,	GAS-GENERATORS, SPACECRAFT-PRO	033009
OST-EFFECTIVENESS, PIPELINES,	GAS-TRANSPORT# /ISTRIBUTION, C	040009
-PLANTS, PEAK-LOADS, BOILERS,	GAS-TURBINES, ELECTROLYSIS# /R	010034
N/ CHEMICALS, CROPS, BIOMASS,	GASIFICATION, WASTE-UTILIZATIO	023201
N, COAL, FEASIBILITY-STUDIES,	GASIFICATION# CONVERSIO	022016
U/ CARRIER, ENERGY-RESOURCES,	GENERAL REVIEW, HYDROGEN, PROD	010035
MICAL, ECONOMICS, ELECTROLYS/	GENERATION, PROCESS, THERMOCHE	010028
ROELECTRIC, ENERGY-RESOURCES,	GENERATION# /, GEOTHERMAL, HYD	010025
PRODUCTION#	GENERATOR, ENERGY-CONVERSION,	023610
TURBOJET, LIFE-C/ CATALYTIC,	GENERATOR, TURBINE, CATALYSIS,	033008
INTERACTI/ PRODUCTION, MAGMA,	GEOTHERMAL ENERGY, ROCK-FLUID-	023004
ROL, SURFACE-WATE/ POLLUTION,	GEOTHERMAL, DETECTION-AND-CONT	050004
RGY-RESOURCES, GENERA/ SOLAR,	GEOTHERMAL, HYDROELECTRIC, ENE	010025
PRODUCTION, THERMOCHEMICAL,	HALIDES, IRON-CHLORIDES, TRANS	021010
WIND-POWER# ENVIRONMENTAL,	HAZARDS, HYDROGEN FUEL-CELLS,	050006
HYDROGEN, BIOLOGICAL-EFFECTS,	HAZARDS, LEAKAGE# /TY, LIQUID-	050003
AIRCRAFT, CRYOGENIC STORAGE,	HEAT-MEASUREMENT, HYDROCARBON-	030009
OMPUTERS, ELECTRIC-BATTERIES,	HEAT-STORAGE# /SES, STORAGE, C	040011
NVERSION, CHEMICAL-REACTIONS,	HEAT-TRANSFER, PNEUMATIC-TRANS	022018
STORAGE# CARRIER, REVIEW,	HOUSEHOLD, DISTRIBUTION, FUEL,	010036
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DUCTION, OFF-PEAK ENERGY#	HYDRIDE, STORAGE, HYDROGEN PRO	043011
SES, CRYOGENICS, FLUIDIZED-B/	HYDRIDE, STORAGE, VEHICLES, BU	043005
IC STORAGE, HEAT-MEASUREMENT,	HYDROCARBON-FUELS# /T, CRYOGEN	030009
ION, UTILIZATION, GAS-COOLED,	HYDROCARBONS, PROCESS-HEAT-REA	020503
PRODUCTION, THERMOCHEMICAL,	HYDROCHLORIC ACID, LEAD-CHLORI	021013
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S, GENERA/ SOLAR, GEOTHERMAL,	HYDROELECTRIC, ENERGY-RESOURCE	010025
ETALLICS/ CONFERENCE, REVIEW,	HYDROGEN EMBRITTLEMENT, INTERM	043006
ALLOYS, CORROSION-PREVENTION,	HYDROGEN EMBRITTLEMENT# /AGE,	052006
S, STORAGE, AUTOMOBILE-FUELS,	HYDROGEN ENGINES# /TAL-HYDRIDE	043007
R# ENVIRONMENTAL, HAZARDS,	HYDROGEN FUEL-CELLS, WIND-POWE	050006
, REV/ SOLAR, ENERGY-OPTIONS,	HYDROGEN FUELS, PHOTOSYNTHESIS	010018
FLAT-PLATES, FUEL-COMBUSTION,	HYDROGEN FUELS# / COMBUSTION,	033013
ENERGY# HYDRIDE, STORAGE,	HYDROGEN PRODUCTION, OFF-PEAK	043011
AMIC-E/ SOLAR, DECOMPOSITION,	HYDROGEN PRODUCTION, THERMODYN	023606

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ACTERIZATION, METAL-HYDRIDES,	HYDROGEN STORAGE, PYROLYSIS, R	043008
GY-RESOURCES, GENERAL REVIEW,	HYDROGEN, PRODUCTION, THERMOCH	010035
CHEMICAL-ANALYS/ ASSESSMENT,	HYGAS, PHENOLS, AGGLOMERATION,	010039
-MODELS, PROPU/ AERODYNAMICS,	HYPERSONIC, AIRCRAFT, AIRCRAFT	030010
STORAGE# SAFETY,	INDUSTRIAL-PLANTS, PRODUCTION,	050005
-CHLORIDES, PYROLYSIS, THERM/	INDUSTRIAL, PRODUCTION, COPPER	021014
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S# CATALYTIC-EFFECTS,	IRON-ADDITIONS, TITANIUM-OXIDE	021017
ION, THERMOCHEMICAL, HALIDES,	IRON-CHLORIDES, TRANSITION ELE	021010
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TEAM-IRON, PRODUCTION, CHARS,	IRON-OXIDES, RESEARCH-PROGRAMS	021020
ST, COAL-GASIFICATION PLANTS,	IRON-SULFIDES# /TROGEN, CATALY	021015
CAL, PRODUCTION, CONDENSABLE/	IRREVERSIBILITIES, THERMOCHEMI	021006
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CES, S/ CARRIER, ALTERNATIVE,	LARGE-SCALE, ECONOMICS, RESOUR	010029
OCHEMICAL, HYDROCHLORIC ACID,	LEAD-CHLORIDES, LEAD-OXIDES# /	021013
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TURBINE, CATALYSIS, TURBOJET,	LIFE-CYCLE-COSTS# /GENERATOR,	033008
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S, LIQUID-HYDROG/ EFFICIENCY,	LIQUEFACTION, CRYOGENICS, FUEL	040106
FECTS, HAZARDS, LEAK/ SAFETY,	LIQUID-HYDROGEN, BIOLOGICAL-EF	050003
OST-ANALYSIS, ECONOMIC-FACTO/	LIQUID-HYDROGEN, COMPARISON, C	010027
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UEFACTION, CRYOGENICS, FUELS,	LIQUID-HYDROGEN# /ICIENCY, LIQ	040106
SORPTION, AUTOMOBILE-ENGINES,	LIQUID-HYDROGEN# /TOMOTIVE, AD	040010
ENT, AUTOMOBILES, AUTOMOTIVE,	LIQUID, EFFICIENCY, COAL-LIQUE	010033
S, ECONOMICAL PRODUCTION, IN/	LIQUID, SUBSONIC, AIR-TERMINAL	030008
-FLUID-INTERACTI/ PRODUCTION,	MAGMA, GEOTHERMAL ENERGY, ROCK	023004
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AL, LIQUEFACTION, COAL-FINES,	MATERIALS-TESTING# CO	022017
LECTRODES, PRODUCTION#	MATERIALS, ELECTROCATALYSTS, E	052005
RROSION-PREVENTION, HYDROGEN/	MATERIALS, STORAGE, ALLOYS, CO	052006
ITY# THIN-FILM, DETECTORS,	MEASURING-INSTRUMENT, SENSITIV	040302
TORAGE, ALLOY-BONDING-THEORY,	METAL-HYDRIDE# ALLOY, S	040008
YDROGEN STORAG/ APPLICATIONS,	METAL-HYDRIDES, COMPRESSORS, H	043009
GE, PYROLY/ CHARACTERIZATION,	METAL-HYDRIDES, HYDROGEN STORA	043008
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PPING, EMBRITTLEMENT, ALLOYS,	MICROSTRUCTURE, TITANIUM-CARBI	040301
IAL-INCENTIVES, / EVALUATION,	NATURAL-GAS, ECONOMICS, FINANC	010040
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ICATION PLANTS, IRO/ AMMONIA,	NITROGEN, CATALYST, COAL-GASIF	021015
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THRUST, EROSION,	NOZZLE-WALLS, THRUST-CHAMBERS#	033012
HESIS-GAS, CHEMICAL-REACTORS,	NOZZLES, OXIDATION-PROCESS# /T	023204
, FORECASTING, PLANNING REVI/	NUCLEAR-REACTORS, ELECTROLYSIS	020504
STORAGE, HYDROGEN PRODUCTION,	OFF-PEAK ENERGY# HYDRIDE,	043011
ESSION TESTS, FUEL-AIR RATIO,	OPTIMIZATION# /MBUSTION, COMPR	033010
SIS# COMMERCIAL, PRODUCTION,	OVERVIEW, ECONOMICS, ELECTROLY	010020
, CHEMICAL-REACTORS, NOZZLES,	OXIDATION-PROCESS# /THESIS-GAS	023204
NES, ELECTROLY/ POWER-PLANTS,	PEAK-LOADS, BOILERS, GAS-TURBI	010034
ASIFICATION, TOXICOLOGY, AIR/	PERSPECTIVES, CRACKING, COAL-G	010037
AL-ANALYS/ ASSESSMENT, HYGAS,	PHENOLS, AGGLOMERATION, CHEMIC	010039
SYNTHESIS# SOLAR,	PHOTOCHEMICAL, BACTERIA, PHOTO	023607
OELECTROCHEMICAL, EFFICIENCY,	PHOTOCHEMISTRY, TITANIUM-OXIDE	020006
CY, PHOTOCHEMIST/ PRODUCTION,	PHOTOELECTROCHEMICAL, EFFICIEN	020006
PHOTOOXIDATION#	PHOTOLYSIS, WATER, CATALYSIS,	023609
PHOTOLYSIS, WATER, CATALYSIS,	PHOTOOXIDATION#	023609
ERGY-OPTIONS, HYDROGEN FUELS,	PHOTOSYNTHESIS, REVIEWS# /, EN	010018
ONVERSION# PHOTOSYNTHETIC,	PHOTOSYNTHESIS, SOLAR-ENERGY-C	023205
LAR, PHOTOCHEMICAL, BACTERIA,	PHOTOSYNTHESIS# SO	023607
SYNTHESIS, MATERIALS-TESTING,	PHOTOSYNTHESIS# /L, SOLAR, BIO	023202
ATION, MICROALGA/ PRODUCTION,	PHOTOSYNTHETIC, ALGAE, FERMENT	023206
, SOLAR-ENERGY-CONVERSION#	PHOTOSYNTHETIC, PHOTOSYNTHESIS	023205
ECHNOLOGY, SAFETY-FACTORS#	PIPELINE, RHINE-RUHR, ENERGY-T	040603
RIBUTION, COST-EFFECTIVENESS,	PIPELINES, GAS-TRANSPORT# /IST	040009
S, ELECTROLYSIS, FORECASTING,	PLANNING REVIEW# /LEAR-REACTOR	020504
, CATALYST, COAL-GASIFICATION	PLANTS, IRON-SULFIDES# /TROGEN	021015
CAL-REACTIONS, HEAT-TRANSFER,	PNEUMATIC-TRANSPORT# /N, CHEMI	022018
ON-AND-CONTROL, SURFACE-WATE/	POLLUTION, GEOTHERMAL, DETECTI	050004
VIATION, CHEMICAL-PROPERTIES,	POWER-EFFICIENCY, SYNTHETIC# /	030007
ERS, GAS-TURBINES, ELECTROLY/	POWER-PLANTS, PEAK-LOADS, BOIL	010034
VAPORATION, SOLAR-ENERGY#	POWER-SYSTEMS, ELECTROLYSIS, E	010032
CHEMICAL-REACTIONS, PROCESS,	PREPARATION, CADMIUM, THERMOCH	010021
E-SOLUTIONS, CURRENT-DENSITY,	PRESSURE-EFFECTS, TEMPERATURE-	020009
CHEMIC/ TECHNIQUE, ECONOMIC,	PROBLEMS, APPLIANCES, ECONOMY,	010024
ON, GAS-COOLED, HYDROCARBONS,	PROCESS-HEAT-REACTORS, STEAM#	020503
THERMOC/ CHEMICAL-REACTIONS,	PROCESS, PREPARATION, CADMIUM,	010021
MICS, ELECTROLYS/ GENERATION,	PROCESS, THERMOCHEMICAL, ECONO	010028
T-EFFECTIVENESS, IRREVERSIBLE	PROCESSES# /SULFURIC-ACID, COS	021009
AE, BACTERIA, CATALYSIS#	PRODUCTION, BIOPHOTOLYSIS, ALG	023203
IRON-COMPOU/ THERMOCHEMICAL,	PRODUCTION, BROMINE-COMPOUNDS,	021016
, R/ DEVELOPMENT, STEAM-IRON,	PRODUCTION, CHARS, IRON-OXIDES	021020
ERSIBILITIES, THERMOCHEMICAL,	PRODUCTION, CONDENSABLE-PRODUC	021006
PYROLYSIS, THERM/ INDUSTRIAL,	PRODUCTION, COPPER-CHLORIDES,	021014
PROD/ DESIGN, THERMOCHEMICAL,	PRODUCTION, COST, EFFICIENCY,	021012
IC-ACID, COS/ THERMOCHEMICAL,	PRODUCTION, EFFICIENCY, SULFUR	021009
IC, AIR-TERMINALS, ECONOMICAL	PRODUCTION, INSULATION-MATERIA	030008
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HYDRIDE, STORAGE, HYDROGEN	PRODUCTION, OFF-PEAK ENERGY#	043011
S, ELECTROLYSIS# COMMERCIAL,	PRODUCTION, OVERVIEW, ECONOMIC	010020
AL, EFFICIENCY, PHOTOCHEMIST/	PRODUCTION, PHOTOELECTROCHEMIC	020006
GAE, FERMENTATION, MICROALGA/	PRODUCTION, PHOTOSYNTHETIC, AL	023206
SAFETY, INDUSTRIAL-PLANTS,	PRODUCTION, STORAGE#	050005
ATER, EQUILIBRIUM-COMPONENTS,	PRODUCTION, THEORETICAL# W	023608
ES, GENERAL REVIEW, HYDROGEN,	PRODUCTION, THERMOCHEMICAL# /C	010035

LIDES, IRON-CHLORIDES, TRANS/	PRODUCTION, THERMOCHEMICAL, HA	021010
DROCHLORIC ACID, LEAD-CHLORI/	PRODUCTION, THERMOCHEMICAL, HY	021013
COMPOSITION, IRON-HYDROXIDES/	PRODUCTION, THERMOCHEMICAL, DE	021019
OLAR, DECOMPOSITION, HYDROGEN	PRODUCTION, THERMODYNAMIC-EFFI	023606
OOLED, HYDROCARBONS, PROCESS/	PRODUCTION, UTILIZATION, GAS-C	020503
GENERATOR, ENERGY-CONVERSION,	PRODUCTION#	023610
ELECTROCATALYSTS, ELECTRODES,	PRODUCTION# MATERIALS,	052005
NOMICS, FINANCIAL-INCENTIVES,	PRODUCTION# / NATURAL-GAS, ECO	010040
PRODUCTION, COST, EFFICIENCY,	PRODUCTION# / THERMOCHEMICAL,	021012
S, INJECTORS, TRANSO/ FLAMES,	PROPELLANT, COMBUSTION CHAMBER	033011
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C, AIRCRAFT, AIRCRAFT-MODELS,	PROPULSION SYSTEM, WIND-TUNNEL	030010
OMPRESSORS, HYDROGEN STORAGE,	PUBLIC UTILITIES# /HYDRIDES, C	043009
L-HYDRIDES, HYDROGEN STORAGE,	PYROLYSIS, RADIATION EFFECTS#	043008
PRODUCTION, COPPER-CHLORIDES,	PYROLYSIS, THERMOCHEMICAL-PROC	021014
HYDROGEN STORAGE, PYROLYSIS,	RADIATION EFFECTS# /-HYDRIDES,	043008
E, ALLOYS, CALCIUM-COMPOUNDS,	RARE EARTH# STORAG	043010
, COMPRESSION TESTS, FUEL-AIR	RATIO, OPTIMIZATION# /MBUSTION	033010
ODUCTION, CHARS, IRON-OXIDES,	RESEARCH-PROGRAMS# /M-IRON, PR	021020
CAL, ECONOMICS, ELECTROLYSIS,	RESEARCH-PROGRAMS# /HERMOCHEMI	010028
TIVE, LARGE-SCALE, ECONOMICS,	RESOURCES, SOLAR-POWER# /TERNA	010029
, DISTRIBUTION, CONSERVATION,	RESOURCES, STORAGE# /RNATIONAL	010019
USTION PROPERT/ ALTERNATIVES,	REVIEW, AUTOMOTIVE-FUELS, COMB	010023
N, FUEL, STORAGE# CARRIER,	REVIEW, HOUSEHOLD, DISTRIBUTIO	010036
, INTERMETALLICS/ CONFERENCE,	REVIEW, HYDROGEN EMBRITTLEMENT	043006
ER, ENERGY-RESOURCES, GENERAL	REVIEW, HYDROGEN, PRODUCTION,	010035
ALTERNATIVES, SURVEY,	REVIEW#	010030
OLYSIS, FORECASTING, PLANNING	REVIEW# /LEAR-REACTORS, ELECTR	020504
DROGEN FUELS, PHOTOSYNTHESIS,	REVIEWS# /, ENERGY-OPTIONS, HY	010018
SAFETY-FACTORS# PIPELINE,	RHINE-RUHR, ENERGY-TECHNOLOGY,	040603
ON, MAGMA, GEOTHERMAL ENERGY,	ROCK-FLUID-INTERACTIONS# /UCTI	023004
HINE-RUHR, ENERGY-TECHNOLOGY,	SAFETY-FACTORS# PIPELINE, R	040603
DUCTION, STORAGE#	SAFETY, INDUSTRIAL-PLANTS, PRO	050005
GICAL-EFFECTS, HAZARDS, LEAK/	SAFETY, LIQUID-HYDROGEN, BIOLO	050003
OLYSIS,/ NETHERLANDS, FOSSIL,	SCENARIO, DISTRIBUTION, ELECTR	010038
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ANODIC-PROPERTIES, SEAWATER,	SELF ACTIVATING-PROPERTIES# /,	034014
ECTORS, MEASURING-INSTRUMENT,	SENSITIVITY# THIN-FILM, DET	040302
ITION, COAL-PREPARATION, FLOW	SHEETS# /COAL, CHEMICAL-COMPOS	022014
LECTROLYTE, ELECTROCATALYSTS,	SILICON CARBIDES# /SULFONIC, E	034012
OTOSYNTHETIC, PHOTOSYNTHESIS,	SOLAR-ENERGY-CONVERSION# PH	023205
S, ELECTROLYSIS, EVAPORATION,	SOLAR-ENERGY# POWER-SYSTEM	010032
-SCALE, ECONOMICS, RESOURCES,	SOLAR-POWER# /TERNATIVE, LARGE	010029
-TESTI/ SUNLIGHT, BIOLOGICAL,	SOLAR, BIOSYNTHESIS, MATERIALS	023202
PRODUCTION, THERMODYNAMIC-E/	SOLAR, DECOMPOSITION, HYDROGEN	023606
N FUELS, PHOTOSYNTHESIS, REV/	SOLAR, ENERGY-OPTIONS, HYDROGE	010018
IC, ENERGY-RESOURCES, GENERA/	SOLAR, GEOTHERMAL, HYDROELECTR	010025
, PHOTOSYNTHESIS#	SOLAR, PHOTOCHEMICAL, BACTERIA	023607
UCTION, CONDENSABLE-PRODUCTS,	SOLUTION CHEMISTRY, WATER-DECO	021006
ES, NICKEL-CADMIUM BATTERIES,	SPACE-VEHICLES, SULFUR-TRIOXID	020007
KE, VEHICLES, GAS-GENERATORS,	SPACECRAFT-PROPULSION# /EROSPI	033009
URIC-ACID# THERMOCHEMICAL,	STATUS, BISMUTH-SULFATES, SULF	021007
HYDRIDES, STORAGE# FUTURE,	STATUS, DECOMPOSITION, NICKEL-	010022

ONFOSSIL, THERMAL EFFICIENCY,	THREE-STEP# N	021018
HRUST, EROSION, NOZZLE-WALLS,	THRUST-CHAMBERS# T	033012
THRUST-CHAMBERS#	THRUST, EROSION, NOZZLE-WALLS,	033012
MENT, ALLOYS, MICROSTRUCTURE,	TITANIUM-CARBIDES# / EMBRITTLE	040301
YTIC-EFFECTS, IRON-ADDITIONS,	TITANIUM-OXIDES# CATAL	021017
, EFFICIENCY, PHOTOCHEMISTRY,	TITANIUM-OXIDES# /CTROCHEMICAL	020006
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MBUSTION CHAMBERS, INJECTORS,	TRANSDUCERS# /, PROPELLANT, CO	033011
CAL, HALIDES, IRON-CHLORIDES,	TRANSITION ELEMENT# /ERMOCHEMI	021010
S, MICROSTRUCTURE, TITANIUM-/	TRAPPING, EMBRITTLEMENT, ALLOY	040301
LIFE-C/ CATALYTIC, GENERATOR,	TURBINE, CATALYSIS, TURBOJET,	033008
ENERATOR, TURBINE, CATALYSIS,	TURBOJET, LIFE-CYCLE-COSTS# /G	033008
ERIES, SPAC/ ELECTROCHEMICAL,	UTILITIES, NICKEL-CADMIUM BATT	020007
ORS, HYDROGEN STORAGE, PUBLIC	UTILITIES# /HYDRIDES, COMPRESS	043009
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LUIDIZED-B/ HYDRIDE, STORAGE,	VEHICLES, BUSES, CRYOGENICS, F	043005
ECRAFT-PROPULSION/ AEROSPIKE,	VEHICLES, GAS-GENERATORS, SPAC	033009
CROPS, BIOMASS, GASIFICATION,	WASTE-UTILIZATION# /HEMICALS,	023201
PRODUCTS, SOLUTION CHEMISTRY,	WATER-DECOMPOSITION# /ENSABLE-	021006
ON# PHOTOLYSIS,	WATER, CATALYSIS, PHOTOOXIDATI	023609
PRODUCTION, THEORETICAL#	WATER, EQUILIBRIUM-COMPONENTS,	023608
HAZARDS, HYDROGEN FUEL-CELLS,	WIND-POWER# ENVIRONMENTAL,	050006
FT-MODELS, PROPULSION SYSTEM,	WIND-TUNNEL-MODELS# /T, AIRCRA	030010
NE-COMPOUNDS, IRON-COMPOUNDS,	ZINC-COMPOUNDS# /UCTION, BROMI	021016
ON, THERMODYNAMIC-EFFICIENCY,	ZINC-OXIDES# /YDROGEN PRODUCTI	023606
N, THERMOCHEMICAL, ECONOMICS,	ZINC-SELENIDES# /-SHEET, DESIG	021011